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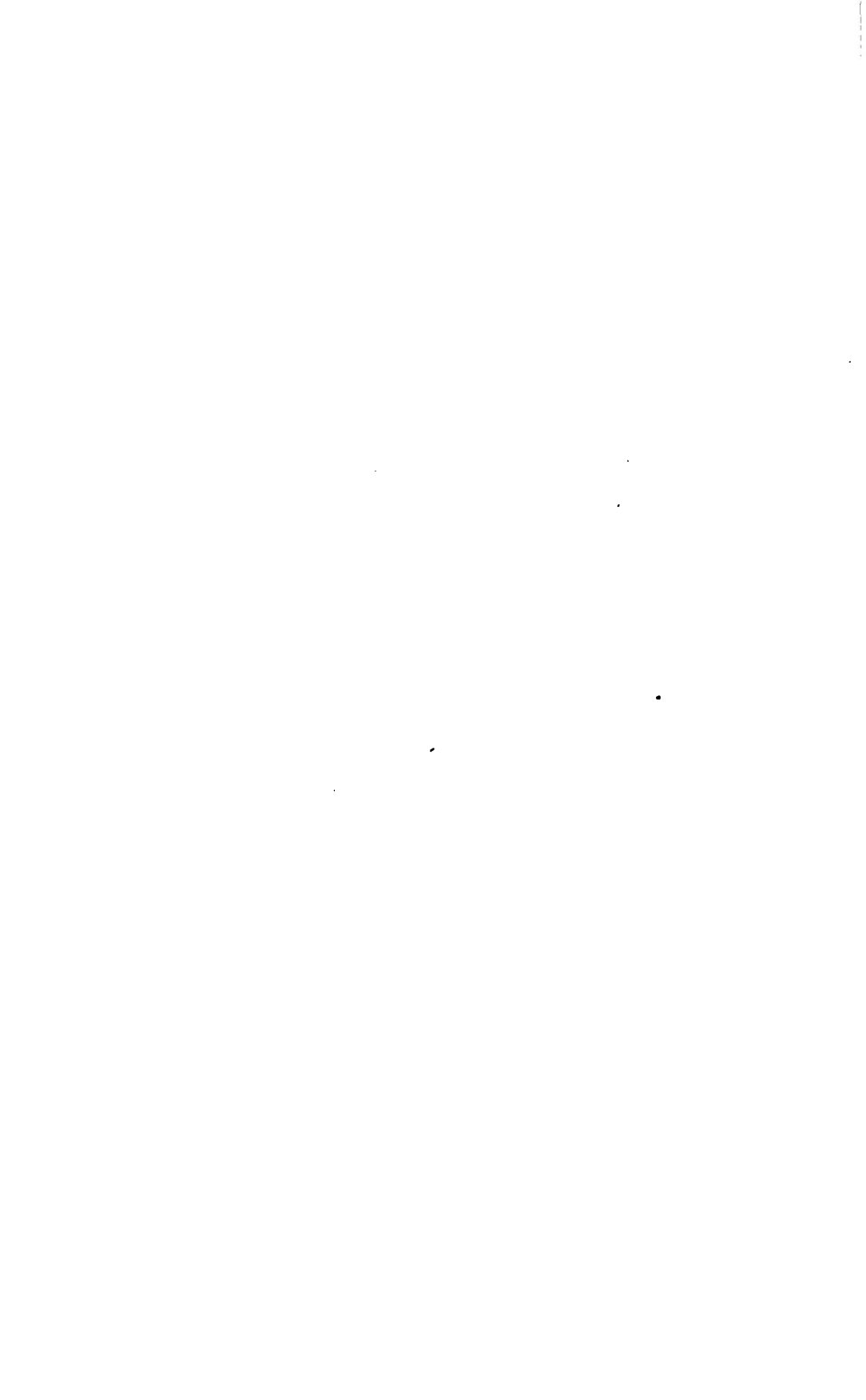
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No. ² II

1900 ✓

THE JOURNAL ✓

OF THE

IRON AND STEEL INSTITUTE

VOL. LVIII.

54

EDITED BY

BENNETT H. BROUGH

SECRETARY

LONDON

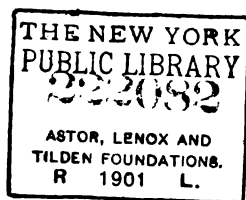
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NEW YORK: SPON & CHAMBERLAIN, 12, CORTLANDT STREET

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28, VICTORIA STREET, LONDON, S.W.

1900 ✓



Printed by BALLANTYNE, HANSON & CO.
At the Ballantyne Press

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1. The first part of the paper is devoted to a discussion of the general principles of the theory of the structure of the atom. It is shown that the structure of the atom is determined by the laws of quantum mechanics, which are based on the principle of the uncertainty of the position and momentum of the particles.

2. In the second part of the paper, the author discusses the problem of the structure of the nucleus. It is shown that the structure of the nucleus is determined by the laws of quantum mechanics, which are based on the principle of the uncertainty of the position and momentum of the particles.

3. In the third part of the paper, the author discusses the problem of the structure of the molecule. It is shown that the structure of the molecule is determined by the laws of quantum mechanics, which are based on the principle of the uncertainty of the position and momentum of the particles.

4. In the fourth part of the paper, the author discusses the problem of the structure of the crystal. It is shown that the structure of the crystal is determined by the laws of quantum mechanics, which are based on the principle of the uncertainty of the position and momentum of the particles.

5. In the fifth part of the paper, the author discusses the problem of the structure of the liquid. It is shown that the structure of the liquid is determined by the laws of quantum mechanics, which are based on the principle of the uncertainty of the position and momentum of the particles.

6. In the sixth part of the paper, the author discusses the problem of the structure of the gas. It is shown that the structure of the gas is determined by the laws of quantum mechanics, which are based on the principle of the uncertainty of the position and momentum of the particles.

7. In the seventh part of the paper, the author discusses the problem of the structure of the plasma. It is shown that the structure of the plasma is determined by the laws of quantum mechanics, which are based on the principle of the uncertainty of the position and momentum of the particles.

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wishing to acquaint himself with the history of our industry for the last quarter of a century. I do not wish to take up your time any longer. I must leave you welcome and I make way for your President, who will preside over your debates. I have no doubt but that this meeting will be as fruitful in good results as all the preceding ones have been. I wish for no better earnest of time than the list of subjects which are going to be offered for your deliberation.

The President who spoke in French replied as follows:—
 For the first time the Iron and Steel Institute as a body, receives the official hospitality of the Société pour l'Encouragement de l'Industrie Nationale. We cannot therefore consider ourselves as strangers, but rather as the invited guests at a friend's house. We feel ourselves at home because of the many members of the Comité des Forges assembled together to receive us, and the friendly relations which subsist between the Comité des Forges and our own Institute. At the same time I regret to see a linguistic barrier but it remains the word "grande" and that is the word I want Mr. Jolyet de Villeval to address to you the feelings of the members of the Iron and Steel Institute, in whose name I have the honour to speak and whom I introduce to you today. The members of the Comité des Forges and of the Institute are most anxious with impatience and anxiety of the occasion of this second International Exhibition a work which is years and years of labour, which shows so nobly the end of the century. We are very glad to bring to you from England our warmest congratulations on the work which France has just accomplished. There is no denying that it is the premisses of the whole world and particularly those of France and England whose industry has given to this century the name of the century of iron. We are most anxious for your reception and we are sure that our meeting will be the many bonds which unite France and England.

M. Henry de Villeval, President of the Comité des Forges said: I thank you for the great honour you have done me in conferring upon me this great the Bessmer medal. I think that

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The PRESIDENT, who spoke in French, replied as follows:—For the third time the Iron and Steel Institute, as a body, receives the cordial hospitality of the Société pour l'Encouragement de l'Industrie Nationale. We cannot, therefore, consider ourselves as strangers, but rather as the habitual guests at a friend's house. We feel ourselves at home, because of the many members of the Comité des Forges assembled together to receive us, and the friendly relations which subsist between the Comité des Forges and our own Institute. My vocabulary, I regret to say, is a limited one, but it contains the word "gratitude," and that is the word I want, Mr. Robert de Wendel, to express to you the feelings of the members of the Iron and Steel Institute, in whose name I have the honour of speaking, and whom I introduce to you to-day. The members of the Comité des Forges and of the Institute can meet together with brotherly cordiality on the occasion of this splendid International Exhibition, a work wholly of peace and good-fellowship, which crowns so nobly the end of the century. We are very glad to bring to you from England our warmest congratulations on the work which France has just accomplished. Does it not remind you that it is the ironmasters of the whole world, and particularly those of France and England, whose industry has given to this century the name by which it will be known by future centuries—that of the "steel age"? We are most grateful for your reception, and we are sure that our meeting will only add to the many bonds which unite France and England.

Mr. HENRI DE WENDEL (Bessemer Gold Medallist) said: I thank you for the great honour you have done me in conferring upon me this year the Bessemer medal. I think that



NAME.	ADDRESS.	PROPOSERS.
Bamber, Herbert Kelway	utta, Bengal, India	Sir William Roberts-Austen H. Kelway Bamber, Septimus Young.
Beard, Herbert . . .	Gartcosh, near Glasgow	Arch. Colville, Thomas Davie, Walter Dixon.
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Bond, Henry Coulson	3 Love Lane, Eastcheap, London, E.C.	J. T. Smith, Ernest Trubshaw, R. Beaumont Thomas.
Charlton, Alfred Johnson	886 Ashton Old Road, Manchester	Edward P. Martin, E. Windsor Richards, Sir William Roberts-Austen.
Charlton, William Johnson	7 Victoria Street, London, S.W.	Edward P. Martin, E. Windsor Richards, Sir William Roberts-Austen.
Cowper-Coles, Sherard Osborn, Assoc. M.Inst.C.E., M.I. Mech.E.	Grosvenor Mansions, Victoria Street, London, S.W.	F. W. Harbord, Thomas Twynan, Edward P. Martin.
Davis, Charles Henry	99 Cedar Street, New York City, U.S.A.	G. E. Macarthy, H. H. Campbell, Walter M. Musgrave.
Dodgson, Thomas Edward	Park Gate Iron and Steel Company, Ltd., Rotherham	Charles Markham, John D. Ellis, C. J. Stoddart.
Dronfield, Joseph Herbert	Descanso, Alexandra Park, Oldham	Henry Webb, Thomas Ashbury, Joseph Gregory.
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Gaunt, John Thomas .	9 Swinburn Road, Eaglescliffe Junction, R.S.O., Durham	John Law Smith, Henry Tomkins, James Bott.
Gaunt, Richard . . .	Albany Villa, Eaglescliffe, R.S.O., Durham	John Law Smith, Henry Tomkins, James Bott.
Gwynne, Thomas . .	Briton Ferry, Glamorganshire	William Evans (Cyfarthfa), Herbert Eccles, Lewis Jenkins.
Harris, Henry Graham, M.Inst.C.E., M.I. Mech.E.	5 Great George Street, Westminster, London, S.W.	E. Windsor Richards, Edward P. Martin, A. Tannett Walker.
Hartley, William Archbold	Cyclops Works, Sheffield	Sir Alexander Wilson, Petronius Hodges, Francis John Maw.
Hasebe, Kosamuro. .	Cyclops Works, Sheffield	Sir Alexander Wilson, Thomas Nash, F. J. Maw.
Head, Benjamin Wrightson, B.A.	47 Victoria Street, London, S.W.	Sir Thomas Wrightson, William Whitwell, Archibald P. Head.
Hedley, George. . .	Messrs. Bolekow, Vaughan & Co., Middlesbrough	Sir Lowthian Bell, David Evans (Middlesbrough), Edward P. Martin.

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NAME.	ADDRESS.	PROPOSERS.
Turner, John Hamilton	129 Trongate, Glasgow	G. MacLellan Blair, J. C. Cunninghame, E. Windsor Richards.
Walker, Archibald	6 Queen's Gate, Dowanhill, Glasgow	James Kerr, W. Howat, John Colville.
Walker, George William	Bridge Works, Wednesday	Sir Benjamin Hingley, H. G. Mantle, George Hatton.
Ward, William John Cuthbert	23 Moor Oaks Road, Sheffield	J. M. While, Albert Senior, Alfred M. While.
Webster, William R.	411 Walnut Street, Philadelphia, Pennsylvania, U.S.A.	John Fritz, Maunsel White, Robert W. Hunt.
Wheatley, George Thomas	Ballengeich, Motherwell, N.B.	William Wylie, James Kerr, John R. Cross.
Williams, Samuel	Ffosyrefel, Pontardulais, Glamorganshire	Edward P. Martin, John R. Wright, Isaac Butler.

THE PRESIDENT-ELECT.

The PRESIDENT said he had one singularly pleasing duty to perform, and that was to announce the name of the new President, who would at the Spring meeting occupy the chair. The choice of the Council, as they would all be glad to hear, had fallen upon Mr. William Whitwell. He had a claim not only of seniority, but of merits of many kinds, which it would be impossible to dwell fully upon. It was a choice the excellence of which would reveal itself when Mr. Whitwell took his place in the chair in May next. This was not the opportunity to dilate on Mr. Whitwell's qualifications for the post, and he would merely add on his own part how glad he was that Mr. Whitwell would be his successor.

THE ANDREW CARNEGIE DONATION.

The PRESIDENT said he had another announcement, also of a pleasing character, to make. It was no less than a communication from Mr. Andrew Carnegie, Vice-President, who, at the conclusion of the last meeting, announced his intention of giving a medal and a scholarship in connection with the Institute, to be devoted to research and for a piece of work of some definite kind. The details were not actually arranged as yet, but he might say that the work would be performed in any university

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Age Group	2002	2004	2006
18-29	~85%	~88%	~90%
30-49	~75%	~78%	~80%
50-69	~65%	~68%	~70%
70+	~55%	~58%	~60%

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present to give information. The members would proceed to the Le Creusot Pavilion, where they would be entertained by Mr. Schneider. A letter had been received from the American exhibitors in mining and metallurgy, who cordially extended a welcome and entertainment to the members visiting the Exhibition.

THE PRESIDENT'S ADDRESS.

The PRESIDENT said he had prepared a Presidential Address which had been beautifully translated into French. He did not propose to read the address in full, in order that they might have more time to see the metallurgical contents of the Exhibition; but he hoped that the members would read it for themselves, and he might say that he wished to emphasise that part of it which showed the close union of the works of France and England in connection with iron and steel throughout the century.

The following is the President's address:—

as an Institute. We are specially grateful to M. Robert de Wendel, President of the Comité des Forges, a Member of our Institute, who presided over the reception committee, which comprised many of the most eminent scientific and industrial men in France. I would also thank the Minister of Public Works, M. P. Baudin, who received us on behalf of the President of the Republic. We were grateful to M. Eugène Schneider, a Member of our Institute, who received us in the Exhibition at the very interesting pavilion of Le Creusot Works. In connection with Le Creusot, I would specially express our thanks to M. Gustave Canet for many acts of kindness, and for the reception which, as President of the *Société des Ingénieurs Civils de France*, he gave me when, earlier in the year, I visited Paris as one of the representatives of our Council. I am able to add, with great satisfaction, that M. Canet is now an Honorary Member of our Institute. As regards the excursions, M. A. de Montgolfier, who is, I am glad to say, also an Honorary Member of our Institute, received us munificently at the St. Chamond Works, while M. Henri de Wendel, our Bessemer Medallist, entertained a party at his works at Hayange and at Joeuf. The President of the Municipal Council of Paris invited us to the Hôtel de Ville, and M. Grébauval's eloquent and appreciative words of welcome will be remembered as one of the noteworthy features of the meeting.

Colonel and Mrs. Jekyll's delightful reception at the English House in the *Rue des Nations* at the Exhibition reminded us how close Paris is to London.

Not the least claim to our gratitude was earned by the generosity of Mr. Henry Chapman, who again placed his offices at our disposal; while the ability and indefatigable

THE ADDRESS.

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"It is an age so full of light, that there is scarce a country or corner of Europe whose beams are not crossed and interchanged with others, but there is none under heaven abounding with more variety of learning, where the sciences may be more fitly wooed or more surely won, than in France." These lines, written by Laurence Sterne in his incomparably clever "Sentimental Journey," were printed in the year 1768, the year in which Lavoisier's genius gained him admission as "Adjoint" to the French Academy, while at the same time the metallurgist Jars became "Membre titulaire." Sterne's is a glowing tribute, but we feel its justice and gladly adopt it as our own.

In the spring of 1899 I reviewed our national progress throughout the century in relation to iron and steel, and expressed the hope that at a future time I might give a similar account of the work in other countries. Our Institute is international, and some fifty of our members are either French or live on French territory; and as this is the third time that the Institute as a body has been hospitably received in France, my address may well be offered as a tribute to her. On both the previous occasions of our visits to Paris, as on the present one, the Société d'Encouragement pour l'Industrie Nationale generously placed its house at our disposal. In 1878 we were received, in the absence of the illustrious chemist, M. J. B. Dumas, then President of the Society, by Professor Gruner, and in 1889 by M. Gustav Eiffel and by M. Haton de la Goupillière. This year the President of the Société is M. Adolphe Carnot; this name, made illustrious by sons of France, who have filled the highest office in her army and in the State, will always be received with deep respect in England, and is imperishably connected with the advance of physical science. In my capacity of Professor at the Royal School of Mines, I am proud to claim M. Carnot as a colleague, and also M. Haton de la Goupillière, who again receives us; for I need not remind you that he presides over the École des Mines Institution, the distinguished professors of which have since its foundation advanced both industry and science. With

The result is remarkable. The metallurgist, by adding small amounts of matter to iron, has literally made it possible to change the aspect of the world. He has enabled such structural triumphs as the Eiffel Tower and the Forth Bridge to be designed and built: he has created the Age of Steel, and of this age the palaces we have come to see on the banks of the Seine are the exponent, both as regards their construction and their contents.

Throughout the century, our nations have worked in unison, and shared the industrial triumphs by which the civilisation of the world has immeasurably gained.

The bonds of literature and of science have, moreover, for centuries united France and England, and the sympathy subsisting between men of letters stimulated industrial advance. In the thirteenth century Roger Bacon graduated as Doctor at the University of Paris before returning to Oxford, where his life's work was done. In the fourteenth century Chaucer translated the "Roman de la Rose." The great Scotch scholar, George Buchanan, an exile at Bordeaux, had Montaigne as his pupil, and Shakespeare in the "Tempest" and in "Hamlet" paraphrases sentences of Montaigne. In the seventeenth century Isaac Casaubon, coming as the guest of King James I., profoundly influenced English thought, and by reviving at Oxford the study of Aristotle, prepared the way for the advance of experimental science in our older universities. In the eighteenth century, Voltaire, meeting Benjamin Franklin in London, rejoices that he can speak his language. The Abbé Prévost translates "Pamela" and "Clarissa Harlow," and makes them known to French readers. Every page of the "Esprit des Lois" proves how much Montesquieu learnt from Englishmen, and especially, it may well be, from those living near his home at Bordeaux, among whom the father of our own great chemist, Black, was prominent. How much may not Black himself have owed to the kindly interest of Montesquieu in those early days on the banks of the Garonne? The literary union of the two countries was close, but the bonds of union in science were firmer and more enduring, as it is natural that they should have been, for the literary men discussed abstractions, the scientific men principles. The correspondence between Lavoisier and Black bears abundant testimony to the

1. The first part of the document is a title page. It contains the title "THE HISTORY OF THE UNITED STATES OF AMERICA" and the author "BY JAMES M. SMITH".

2. The second part of the document is a preface. It discusses the author's purpose in writing the book and the scope of the work.

3. The third part of the document is the main body of the text. It is divided into several chapters, each covering a different period of American history.

4. The fourth part of the document is a conclusion. It summarizes the main points of the book and offers some final thoughts on the history of the United States.

5. The fifth part of the document is an index. It lists the names of people, places, and events mentioned in the book, along with the page numbers where they can be found.

found expression in lines of his which embody a metallurgical simile, and run as follows:—

“If matter cannot be destroyed,
The living mind can never die.
If e'en creative when alloyed,
How sure its immortality.”

Gay Lussac, Thénard, Laurent, and Le Play were personally known to Dr. Percy, my predecessor in the chair at the Royal School of Mines. Of the two first-named he writes in 1864, “Both are in their graves, and both bequeathed to France a legacy of fame of which she may well be proud. . . . Laurent also is dead, Le Play survives.” Of Le Play, may not we who have seen the glorious Exhibition of 1900 remember how much this great metallurgist did in organising the Exhibitions held in Paris in 1855 and in 1867, at the latter of which he was Commissaire Générale.

The names of two more illustrious Frenchmen to which I would refer in this introduction are those of men who were personally known to some of us, and they connect us directly with the past. These are Jean Baptiste Dumas and Henri Saint-Claire Deville. Dumas was born in the year 1800, and stands first among the chemists of the nineteenth century. When I first met him in 1870, he was Director of the Mint, and it would be difficult to say whether his distinguished manner owed more to gravity or to benignity, outward signs of the qualities of his heart which at once inspired respect and affection. I ask you to join in my tribute to his memory mainly because he represents a grand feature in French science, the union of theory and practice. He illuminated every elaborate research he undertook with the penetration of an inventive genius, and yet turned again and again to the consideration of industrial problems. Recognising their vast importance to the nation, he founded the École Centrale des Arts et Manufactures, where M. Jordan was professor until his lamented death in the present year deprived us of a distinguished member. Among those who have gone the only other memory on which I will dwell is that of Henri Saint-Claire Deville. Reference will be made to his work later on, and beyond offering these few words of personal tribute, I will

tropy of iron, the pen being of harder iron than the steel on which it wrote.

If further justification is demanded, I would plead, in these days when due allowance is made for the influence of environment, that this address was written in the Mint, in full view of the one building in London which, more than any other, specially reminds us of France—the Tower of William the Norman. The turret is before me in which I like to think that, in the fourteenth century, the erratic pupil of Arnaud de Villeneuve, Raymond Lully, worked. French names, moreover, are in constant use in conducting our daily operations of coinage. We in the Mint consult almost hourly tables calculated by Gay Lussac, and the “*Traité des Essais*” of Berthier, whose other writings are still my text-books.

The new century was not three years old when communications of the utmost importance appeared in each of our respective countries. In France, in 1803, Claude Louis Berthollet published his brilliant “*Essai de Statique Chimique*,” and in England, Dalton, in the same year, gave to the world his atomic hypothesis, which enabled chemistry to be built up upon a new basis. From that time, in all countries, science has advanced more or less on the lines laid down by these great thinkers; that is, the guiding ideas have either had reference to the *mass* of Berthollet or the *atom* of Dalton. We may follow these lines in recording the metallurgical history of the century, but it will be necessary to trace the industrial applications of science by a third line, connected by links with each of the other lines. By dividing the century into periods, it will be possible to follow the direction, or at least to consider the relations, of these lines without confusion. Along Berthollet’s line may be ranged all results which involve the action of mass and cannot be attributed to fixed atomic proportions, while, on the other hand, the course indicated by Dalton involves recognition of the atomic constitution of matter.

It must never be forgotten that both our nations had already turned to Sweden, where theory and practice were united, where the reputation of the pure iron of Dannemora was worthy of the teaching of Upsala. In the great university of that city, Bergman, by pointing to carburisation as the fundamental principle

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taken the lead. In 1820 MM. Boiguer and Dufand at Fourchambault, and M. François de Wendel at Hayange, had built extensive works which served as models for others. I need not remind you that his distinguished successor, M. Henri de Wendel, is our Bessemer Medallist this year.

As an indication of the progress which French metallurgy had made, it may be added that in the Exhibition of 1834, MM. Jackson Frères, the sons of William Jackson, exhibited an ingot of cast steel weighing nearly half a ton. Seventeen years later, at our own Exhibition of 1851, our heaviest steel mass was only a ton and a quarter, though Krupp showed an ingot of double the weight.

The London Exhibition of 1851 fittingly begins the second half of the nineteenth century.

The first halting-place in physical work must be made at the splendid calorimetric researches conducted in the fifties by Favre and Silbermann, to whom and to Andrews of Belfast we are indebted for the most trustworthy work on the subject. Then came a glorious period of French science, which the work of Henri Saint-Claire Deville adorned. Had he left nothing else than his researches on Dissociation, he would have more than earned our homage in connection with the metallurgy of iron and steel. By bringing into line chemical dissociation and evaporation, and chemical decomposition and ebullition, the researches of Deville gave the views of Isaac Newton on chemical action, so long misunderstood, the most startling confirmation. In France, the country of so many great metallurgists, the school of Deville has done admirable service, not only in developing his work, but in bringing the results of his labours and teaching within the range of practical men.

Every ironmaster now knows how important in the practice of the metallurgic art, and especially in connection with the blast-furnace, are the incomplete chemical processes which tend to re-form the identical substances with which a given operation started. The result of such opposed processes is the state of chemical equilibrium in which both the original and the newly formed substances are present in definite proportions, which remain unaltered so long as the conditions, more especially as to temperature and pressure, remain unchanged.

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materials which possess such strange and novel qualities to suitable thermal treatment became evident. In this way the period between 1889 and 1900 is reached, and this period I have already characterised by the word "intensity." No process of marked novelty has been devised, though there have been modifications and developments of the existing processes, and the scale on which they are conducted has been greatly increased. The investigators have in many cases been the same as in the preceding decade, but there has been intensity of aim and concentration of effort in bringing physical methods, and the results of investigation in pure science generally, into line with industrial requirements. In effecting this our two countries have worked in unison. Progress has been made mainly in two directions:—

1st. The preparation of new alloys of iron.

2nd. The study of the properties of iron and its alloys.

Alloys of iron and chromium present a remarkable instance. Berthier prepared the first alloy of chromium and iron in 1820, and Roussingault also devoted some attention to them. Brustlein had manufactured these alloys in the works of Jacob Holtzer, since the year 1877; but the Exhibition of 1889 first made us familiar with rich alloys containing 84 per cent. of chromium. In 1900 we find Brustlein renewing his efforts, and we are glad to welcome him on the jury of the metallurgical class. Chrome steels have passed beyond the crucible stage, and are prepared on the open-hearth with 3 per cent. of chromium, as is also a triple alloy of iron, chromium, and nickel for use as armour plate and in artillery. As regards our English efforts, we all know how much Huchfeld has done in extending the use of iron and chromium alloys for projectiles. At about the same time that Berthier gave us the first alloy of iron and chromium Palmieri prepared the first specimen of an alloy of iron and nickel the nature of which has proved to be so great. In the year 1884 M. Matheson of the Société Ferro-Nickel produced their first alloy under the name of *alloy* at the works at Lixy-sur-Orny, while at the Paris Exhibition of 1889 the Société showed the new alloys of iron with varying proportions of nickel. The Journal on our literature for the year 1896 contains a paper by James Smith on the "Alloys of Nickel and Steel," which will

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did for this great branch of manufacture. The magnificent exhibits of iron-manganese alloys in the present Exhibition testify to the increased importance of the work which M. Jordan so recently directed. In England ferro-manganese was produced at the Pyle and Blaina Works, at Mostyn, at Darwin, at Wigan, and at the works of Messrs. Bolckow, Vaughan, & Co. At the time of the former Exhibition in Paris, 1889, England was the dominant user.

I need not remind you that Hadfield, about the time of the former Exhibition in Paris, astonished the metallurgical world by producing steel containing from 7 to 21 per cent. of manganese, and possessing remarkable properties. His later work on the same alloys has only served to intensify interest in his earlier investigations, and it affords another instance of the renewed efforts which characterise the last decade. I will not weary you by passing in review the other alloys of iron, such as those with silicon, tungsten, and titanium; but I must not omit reference to the researches of MM. Moissan and Charpy on boron steel, of which we shall hope to hear much more in the future. May we not hope that in the next century vanadium, uranium, molybdenum, and even glucinum, will prove as faithful allies as certain of the better-known metals have been.

The second direction in which efforts have been intensified is in the study of the properties of iron and its alloys. The investigations may be conveniently divided thus:—

- a. Those which relate to the physical properties of iron and its alloys, as revealed by thermal measurement.
- b. Those which have for their object the study of the structure of iron, and the grouping of the constituents in its alloys as revealed by the microscope.

The work that may be ranged in both of these groups had an earlier origin than is quite realised at the present day. As regards pyrometry, which occupies a prominent place in the first group, space absolutely forbids my attempting to give a history of the blended efforts of our two countries, and I must only permit myself to recall a few of the more prominent names, and not pass beyond the limits of the present

1. The first step in the process of creating a new product is to identify a market need. This involves conducting market research to understand what consumers want and what problems they are facing.

2. Once a market need is identified, the next step is to develop a concept. This involves brainstorming ideas and creating a prototype of the product.

3. The third step is to create a business plan. This involves determining the costs of production, the pricing strategy, and the marketing plan.

4. The fourth step is to secure funding. This can be done through various means, such as seeking investors, applying for grants, or crowdfunding.

5. The fifth step is to manufacture the product. This involves finding a manufacturer and overseeing the production process.

6. The sixth step is to launch the product. This involves creating a marketing campaign and distributing the product to the target market.

7. The final step is to monitor the product's performance. This involves tracking sales, customer feedback, and market trends to ensure the product remains competitive.

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nature of iron itself had been recognised in Bergman's classical phrase, "*polymorphum ferrum*." As the century closes it is seen that iron has gathered to itself, often in considerable volume, numerous associates with which it was originally entrusted only in small quantities. Industry has consequently been enriched by varieties of metal possessing properties hitherto unknown. These properties have been investigated by a host of workers, and the mention of only a few names may seem to be invidious. Nevertheless, I am satisfied that when writers come to look back to the end of this century, as we do to its beginning, the phenomena connected with iron and steel to which they will revert will be comprised in the words "points of transformation." Our country will receive its share of these retrospective thoughts, for the names of Gore and Barrett are waymarks. Tchernoff will be remembered, for he proposed a thermometric scale by which manufacture of steel could be controlled.

From among Frenchmen one name will arise in the memories of future historians of metallurgy, and that name will be Osmond. It will not be forgotten how much Osmond did in defining the modes of existence of carbon in steel. It will be remembered that by his observations a single point of recalescence became resolved into many points. He traced the influence of hysteresis, and showed how the position of the points of transformation vary, within a certain range of temperature, with the element with which the iron is allied. He showed that if a certain variety of steel has been quenched at a point above or below its critical point, it may present one or other of two states of equilibrium. These may be widely different, either as a consequence of change either in the allotropic state of one of the constituents or in the chemical grouping at the moment the metal passes the critical point. I am not unmindful that M. Grignon, who translated Bergman's "*De Analysi Ferri*" into French, shared his views as to the allotropy of iron, nor do I forget that Cizancourt pronounced advanced views on the subject in 1865, as did also Tait in the Rede Lecture delivered at Cambridge in 1873. Osmond, in fact, insisted on the allotropy of iron, proved its fundamental importance, and identified himself with its study, but that, though it is his great achievement, is far from being his only one. He showed

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this quaint and accurate observer, is full of interest, and might almost have been written by any of us to-day :—

“If to these analytical data observations under the microscope with a magnification of 300 to 400 diameters be added, it is seen that ordinary iron is merely a metallic network with a close-grained tissue with submerged scoriaceous opaline, sometimes subcrystalline, portions, and with little globules and metallic grains ranged in every direction. Sometimes nests of translucent prismatic and bacillary crystals, with metallic portions adhering, are noticed hidden in the paste. These are the grains of steel which can be made to disappear by heating.”

England in turn in 1864 gave a new impetus to this important branch of investigation by the labours of Sorby, in whose admirable work polished and etched sections were employed. The microscope as an implement of research hardly received due recognition until Osmond published a classical series of researches which have earned the lasting gratitude of investigators. In no branch of my subject do I so much regret that the limitations of space have obliged me to confine myself to the bounds of our two countries, as I should like to have dwelt on the micrographic work of Martens, Sauveur, Behrens, and many others. I will only add that the work of Stead deserves special recognition, not only for its minute accuracy, but for its originality. Quite recently Ewing and Rosenhain have obtained most interesting results, which go far to explain by micrographic evidence the elasticity and flow of metals, and also the mode by which crystals grow in metallic masses.

A Report of the Departmental Committee on Steel Rails recently issued is the first Government publication in England in which the importance of micrography has been recognised.

Scientific discoveries have during the century worked a complete change in our intellectual appreciation of natural phenomena, but in our work the standpoint of the new century will be singularly like that of the old. A few tenths per cent. of carbon hidden in iron still dominates our branch of metallurgy. Bergman recognised this before the nineteenth century began, and insisted both on the polymorphy of iron and the importance of carbon in relation to it. He pointed out, moreover, that in every great change effected in the constitution of



some instances which readily present themselves. The carburisation of iron offers the first case in which the diffusion of solids in solids was observed. The study by metallurgists of the associations of carbon and iron has elucidated the most complicated case yet known, and indeed the only one which has been worked out, of metallic solid solutions. It presents, moreover, a unique case of the importance of allotropy in connection with metals. In 1000 parts of steel, 997 parts, more or less, may be iron and the rest carbon, but the result of the union is a metal that is more widely used and has more varied attributes than any other. It would seem that nature has enshrined in steel a series of her most complex secrets which we must discover as a condition of our successful use of it. Metallurgists have carefully investigated, and conduct daily, operations of vast industrial importance, in which the presence of a third body enables either elementary bodies or compounds to react on each other. By habitually conducting operations at high temperatures, which often invert ordinary chemical reactions, the metallurgist has acquired a mass of information as to the reactions that do occur, and the compounds that are formed under such conditions. Pyrometric records have, moreover, enabled the equilibrium of the less fusible metals in their liquid as well as in their solid state to be studied—a branch of work which chemists generally have not been in a position to undertake. The necessity for submitting the physical and mechanical properties of iron and its alloys to rigorous tests, as a routine operation in Works, has afforded a rich store of information as to the molecular constitution, not only of metals, but of matter generally. Metallurgists have to deal with cases in which a mass of metal is acted upon by added matter in proportions that are too minute to intervene directly by the formation of chemical compounds with the whole of the mass, while in some cases no compounds are formed. The influence of the atom must, therefore, be more or less directly exerted. Hence it is that we, who still conduct processes, the traditions of which came down to us from mythological times, have done our share in “giving the old Greek atomism a modern and a higher consecration.”

APPENDIX

THE statement as to a vote in the troubled days of 1848 of a sum towards defraying the cost of Regnault's research was made on the authority of M. J. B. Dumas, who, in his charming *éloge* of Victor Regnault (*Discours et Elojes Académiques*. Paris: Gauthier Villars, tome ii., 1885), states that the Société des Ingénieurs de Londres, struck by the beauty of Regnault's results, wished to place at his disposal the necessary funds for the continuance of his experiments. He adds (p. 185): "On aime à rappeler ce vote libéral des ingénieurs anglais, constatant une fois de plus que la science appartient au monde civilisé et qu'elle ne connaît pas de frontières." Dumas thus definitely alludes to a "vote;" but he was, as it proves, imperfectly acquainted with the circumstances, and I was unable to test the accuracy of his information in time for the delivery of the Address. I have, however, by following an indication given me by my friend, Prof. Henri Le Chatelier, satisfied myself, though with great difficulty, as to the facts. It appears that what M. Dumas believed to be "ce vote libéral des ingénieurs anglais," was really a generous offer of an individual engineer, the late Mr. R. S. Newall, who wished Regnault to accept £500 "to enable him to complete his experiments on steam," as is recorded in a note in Mr. Newall's writing, which Mrs. Newall has most kindly shown me. The offer was not accepted, for the French Government supplied the necessary funds, and, as M. Dumas correctly states, "La France pourvut elle-même à la continuation de l'œuvre commencée et que reste son œuvre." It has seemed to me to be in every way desirable that this interesting episode in international scientific history should be in all respects correctly described, hence the addition of this Appendix.

The following paper was then read:—

These figures show that the production of mineral fuel has increased 43 per cent. during the period under consideration, and that the increase has chiefly taken place in the coalfields of Nord and Pas-de-Calais, where it represents nearly two-thirds of the total rise. The great activity of the metallurgical industries in these departments during recent years, and the difficulty of obtaining sufficient coke from Germany, have contributed to the development of the production of the local collieries.

All the different coalfields, except two of minor importance, have progressed, but in a very unequal degree, as is shown by the following table:—

	Increase. Per Cent.
Nord and Pas-de-Calais	57
Loire	23
Bourgogne and Nivernais	47
Gard	7
Tarn and Aveyron	55
Centre	18

The next table indicates the source whence the coal consumed in France was derived, and shows that the home production was only about three-quarters of the amount used.

	1888.	1898.
	Metric Tons.	Metric Tons.
Home production	22,122,500	31,378,000
Coal imported from England	4,108,000	5,486,000
Coal imported from other countries	6,443,500	6,431,000
Total imports	10,551,500	11,917,000
Total consumption	32,674,000	43,295,000

Ironworks play a very important part in this consumption. Even omitting the numerous works employed in the further treatment of the metal, in 1898 they used 2,622,000 tons of coal and 3,200,000 tons of coke, or altogether 7,400,000 tons of raw coal besides 16,000 tons of charcoal. This quantity is as much as is used by the collieries and the railways together, so that the combined consumption of those three industries represents more than a third of the total consumption of France.

According to the provisional statistics for last year, 1899, the total production of coal and lignite in France amounted to

furnace has increased from 18,500 to 24,000 tons. It has attained to 30,000 in the departments of Meurthe-et-Moselle and Nord, and to as much as 40,000 tons in Pas-de-Calais, where the material treated consists almost entirely of Bilbao ores, specular ores from Elba, and the manganiferous ores from the south of Spain, and of which the iron contents are far higher than those of the oolitic ores in the eastern districts.

The average consumption of coke per ton of iron was 1·260 ton in 1898. In 1888 it was only 1·168 ton, and this difference is due to the different quality of the coke and to the lower yield of the ore at the present time.

The manufacture of charcoal iron has become very insignificant. It is carried on in five departments—Charente, Dordogne, Landes, Haute-Marne, and Haute-Saône—simply because of a small demand for special qualities. The same may be said of the iron made with a mixture of charcoal and coke, which is only produced in Cher and Haute-Marne for foundry-work. These two kinds together do not amount to a hundredth part of the total production.

Disregarding the kind of fuel used, the production of iron may be classified according to its intended use as follows:—

	1888.	1898.	Increase.
	Metric Tons.	Metric Tons.	Metric Tons.
Forge iron for puddling and steel-making .	1,306,400	2,018,000	711,600
Foundry iron	313,100	417,100	104,000
Direct castings	63,800	90,000	26,200
Totals	1,683,300	2,525,100	841,800

The production of ferro-manganese and other special iron included with the forge iron above, was 10,692 tons in 1898, and was 1140 tons less than in 1888.

Although twenty-two departments were producing pig iron in 1898, only seven had an annual out-turn of over 50,000 tons. The following table shows the production according to the departments classed in groups:—

As regards forge iron, Meurthe-et-Moselle, with its production of 1,152,500 tons, of which 682,300 tons is basic pig, makes 57 per cent. of the total. The departments of Nord and Pas-de-Calais, which constitute the next group in order of importance, are far behind with 367,000 tons. Seventy-nine per cent., or 328,400 tons of the foundry iron, are also produced in Meurthe-et-Moselle, which is followed by Loire-Inférieure and Haute-Marne. None of the other departments produce more than 10,000 tons. For direct castings Meurthe-et-Moselle takes the lead with 69,700 tons, or 77 per cent. of the total.

Nearly the whole (over 99 per cent.) of the direct castings made in France are produced in five works—The Société anonyme des Hauts-Fourneaux et Fonderies de Pont-à-Mousson and the Société anonyme Mécanique d'Antrives et Villerupt, both in Meurthe-et-Moselle; the Société Mécanique du Périgord at Louche-la-Clayette; the works at Montluçon in Allier belonging to the Société anonyme de Commentry-Forchambault et Chagny et al. and the Société anonyme des Hauts-Fourneaux et Fonderies de Nevers et de Sully-Marne.

The export trade of Meurthe-et-Moselle, where even now the production of pig iron predominates so greatly, is still on the scale of the last years. The new industrial resources have already been reduced to the two new blast-furnaces have been built and which, if carried to completion, will soon be put to work. It is to be observed that the most modern plants are to be found. A certain new furnace has been started, and nearly all those which were in existence in 1888 have been replaced since which the last ten years having with their hot-blast stoves and blast-furnaces it goes to increase their production. The only reduction is that in 1901 there is a certain furnace which is being built at the same time as the others, and it is to be seen.

The new industrial resources, which are a tendency to increase the production of pig iron, are to be seen in the new blast-furnaces and hot-blast stoves which are being built at the same time as the others, and it is to be seen. The new industrial resources, which are a tendency to increase the production of pig iron, are to be seen in the new blast-furnaces and hot-blast stoves which are being built at the same time as the others, and it is to be seen.



through twenty departments, of which the leading ones are given below in the order of their out-turn :—

	Puddled Iron. Metric Tons.
Nord	225,930
Ardennes	62,773
Haute-Marne	53,889
Meurthe-et-Moselle	36,189
Saône-et-Loire	31,662
Loire	28,089
Allier	19,737
Jura	16,737
Oise	12,921
Ariège	12,304

The production in the department of Nord is thus accountable for 42 per cent. of the total.

The order of importance of the different districts as regards the yield of re-manufactured iron is practically the same as for puddled iron, with one exception. The department of the Seine takes the second place, although no puddling is carried on, with a production of 37,000 tons, mainly in the form of girders.

The increase in the output of re-manufactured material shows that it is more profitable to work up some kinds of old iron and scrap rather than to melt it down in the open-hearth furnace. This work is the mainstay of many small and scattered businesses which depend on a limited local demand for small sections.

The nature of the products in these two years is given in the table below :—

	1888.	1898.
	Metric Tons.	Metric Tons.
Merchant and special iron	699,100	695,700
Rails	800	200
Sheets and plates	117,100	70,500
Totals	817,000	766,400

Forty departments have contributed to these totals, but the combined output of eleven of them did not exceed a thousand tons. Steel tends to replace wrought iron altogether in the manufacture of sheets, and even of rails, which were only made of wrought iron in 1888, when they were of light section. The manufacture of merchant and special irons has, however, remained practically constant during the decade.



The production of basic steel, which was only 37 per cent. in 1888, has increased to 58 per cent. of the total product in 1898.

The following table gives an account of the nature of the products made by the two processes in 1898:—

	Bessemer.	Open-Hearth.	Total.
	Metric Tons.	Metric Tons.	Metric Tons.
Rails	237,165	5,641	242,806
Sheets and plates	77,662	196,691	274,353
Merchant steel and special products, } including cannon, forgings, axles, springs, and tires }	347,550	260,431	607,981
Castings	9,300	10,000	19,300

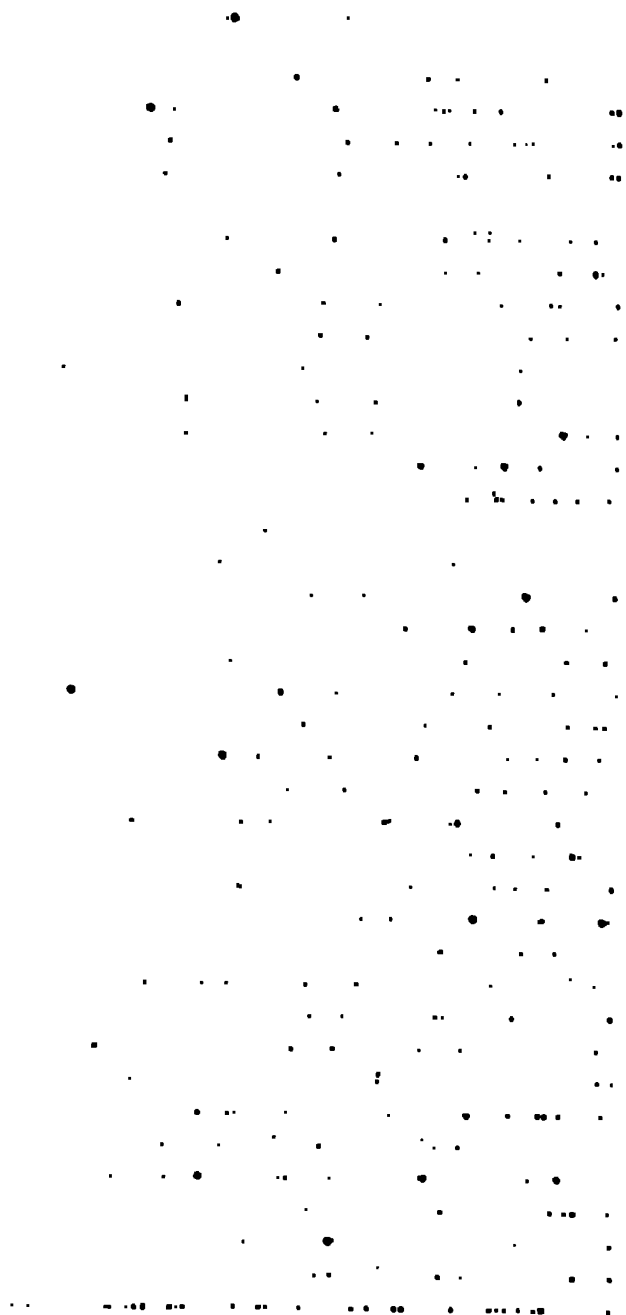
Steel rails were rolled in eleven departments, but as a matter of fact 96 per cent. of the total was produced in six departments, where heavy sections for the great railway lines are made. In order of production these were:—Nord, 60,000 tons; Meurthe-et-Moselle, 54,000 tons; Pas-de-Calais, 46,000 tons; Gard, 51,000 tons; Landes, 25,000 tons; Loire-Inférieure, 18,000 tons.

Bessemer Steel.

Eleven departments have contributed to the total of the production of Bessemer steel, and the leading ones are as follows:—

	1888.	1898.
	Metric Tons.	Metric Tons.
Meurthe-et-Moselle	150,800	526,800
Nord	87,800	120,000
Pas-de-Calais	61,500	65,800
Saône-et-Loire	32,700	62,200
Landes	37,100	45,300
Gard	24,300	32,000
Loire-Inférieure . . . . .	...	25,300
Loire	4,000	...
Totals	398,200	877,400
Other departments	5,100	6,200
Grand totals	403,300	883,600

The 5000 tons in 1888 and the 6200 tons in 1898 were steel castings made with the aid of special small converters, of which



works of the Compagnie des Mines, Fonderies et Forges d'Alais at Bessèges in Gard; and the works of the Société anonyme des Aciéries, Hauts-Fourneaux et Forges de Trignac at Trignac in Loire-Inférieure.

The production of ingots and castings of Bessemer steel in 1899 was 930,800 tons, that is, 47,200 tons, or 5 per cent. more than in the preceding year.

Open-Hearth Steel.

During 1898 open-hearth steel was made in twenty-one departments, to the extent shown by the following table, which gives the figures for 1888 for the sake of comparison:—

	1888.	1898.
	Metric Tons.	Metric Tons.
Nord	12,800	98,000
Saône-et-Loire	35,380	80,709
Loire	45,700	60,881
Loire-Inférieure	8,667	46,603
Allier	11,800	38,182
Gard	20,029	33,704
Nièvre	9,000	25,824
Morbihan	12,500	25,106
Oise	2,258	22,307
Meurthe-et-Moselle	1,635	18,525
Haute-Marne	3,405	17,376
Aveyron . . . . .	...	17,039
Pas-de-Calais . . . . .	...	12,729
Landes	2,132	10,626
Ardennes	3,930	8,680
Isère	2,836	6,986
Meuse	4,950	6,522
Jura	6,870	5,843
Ariège	1,421	5,231
Haute-Rhin	3,144	4,910
Doubs . . . . .	...	4,347
Totals	188,457	550,121

This production was obtained from fifty-nine furnaces in 1888, and from eighty-five in 1898, so the average annual out-turn per furnace has increased from 3225 to 6472 tons, or 100 per cent. There are now thirty-five works containing open-hearth furnaces, as against eleven with Bessemer converters, neglecting the small converters for special castings, but no particular department has a preponderating position in the manufacture, as is the case with

AMERICAN MEDICAL ASSOCIATION

PUBLISHED WEEKLY

CHICAGO, ILL., U.S.A.

Vol. 10, No. 1, January 1917

Subscription price, \$5.00 per annum in advance

Single copies, 15 cents

Entered as Second-Class Matter

May 22, 1902

Postpaid

Under

Authority of

Act of

October 3, 1917

Act of

October 3, 1917

Act of

October 3, 1917

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produced 500 tons ; Tarn, 200 tons, and Isère, 180 tons, and there were thirty-nine furnaces.

c. Crucible cast steel was made in the departments of Loire, 11,800 tons ; Tarn, 1600 tons ; Allier, 1200 tons ; Ardennes, 845 tons ; Isère, 608 tons ; Nord, 250 tons, and elsewhere. Altogether ten departments contributed, the number of furnaces being fifty-three, with 664 crucibles.

To the production of various kinds of steel mentioned above may be added the out-turn of re-manufactured old steel, which was 9900 tons in 1888, 5300 tons in 1898, and 9000 tons in 1899. This gives the following totals for the steel made in France in three years :—

	1888.	1898.	1899.
	Metric Tons.	Metric Tons.	Metric Tons.
Production	625,460	1,459,300	1,564,300

External trade in steel has not suffered any great change, as will be seen from the following table :—

	1888.	1898.	Increase.
	Metric Tons.	Metric Tons.	Metric Tons.
Imports	10,000	10,300	300
Exports	35,200	72,200	37,000

RECENT PROGRESS.

Not only has there been great progress in the iron and steel industry, as shown by the preceding statistics, but many and important changes have been made in plant and machinery, and in the composition and quality of the products.

In Bessemer steelworks, the principal innovation, especially in the eastern districts, consists in the employment of metal mixers, which not only ensure a more regular composition in the iron used, but also desulphurise it and render the steelworks independent of blast-furnace variations. The basic converter has also been subjected to several improvements in details, to

[The page contains faint, illegible markings and noise.]

DISCUSSION.

The PRESIDENT said he need not express the gratitude of the members for such an acceptable paper.

Mr. GREINER, Member of Council, said: I owe probably to my position as a foreign member of the Institute Council, the honour of saying a few words on the subject of the paper which has just been read to you, for really I do not know that I have any other authority. It is, nevertheless, sufficient to allow me to say that we must proclaim the work of Mr. Pinget to be of the greatest interest and merit. He gives us a very complete history of what has been done in France during recent years, and if, as the author very truly says, no great inventions have been forthcoming in the metallurgical world, it is none the less true that France has been found to be a very fertile country in applying the inventions of recent years; and with regard to what concerns me more particularly, I can say that there is probably no other country which has better understood the application of the scientific ideas of recent years than France; there is probably not a country where they make steel and iron, but especially steel, so carefully and so scientifically, and produce such varied and such excellent work as in France. I give this testimony before Englishmen. I am quite certain that no one will contradict me. The number of Frenchmen who have devoted their lives to forming and producing steels of a delicacy and of an excellence which is to-day known throughout the world is a very large one. From this point of view Mr. Pinget's paper deserves to be read. I think that the whole meeting would like to join with me, and that I shall be the interpreter of the Iron and Steel Institute in thanking its author for having presented it to us in such a clear and striking manner as he has done.

Sir LOWTHIAN BELL, Bart., Past-President, said the review of the progress of the science which it had been their duty to cultivate for a great many years was of very great importance. He had read the paper, and he could speak with some little authority upon it, and he ventured to say that there was no

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IRON AND PHOSPHORUS.

By J. E. STEAD, F.I.C.

PART I.

ACCORDING to^(*) Dr. Percy,* no less than seven definite chemical compounds of phosphorus and iron, or at least compounds containing definite atomic proportions of these elements, have been isolated. They are as follows:—

	Fe ₂ P.	Fe ₃ P.	Fe ₅ P.	Fe ₄ P ₃ .	Fe ₃ P ₄ .	FeP.	Fe ₃ P ₄ .
	Per Cent.	Per Cent.	Per Cent.	Per Cent.	Per Cent.	Per Cent.	Per Cent.
Iron . . .	91.54	84.42	78.32	70.67	69.31	64.37	57.54
Phosphorus	8.46	15.58	21.68	29.33	30.69	35.63	42.46

Since Percy's time no very elaborate research has been made, but various workers have added to our knowledge from time to time. What has been done in recent years, however, has enabled metallurgists to see that they had yet much to learn, and that the last word has not been written about the relation which exists between iron and phosphorus.

Excepting in a short note by ⁽⁸⁾ Professor Arnold, there has been little published respecting the microstructure of iron and steel containing phosphorus; and as this branch of the research has practically remained untouched, I have, with the co-operation of a large number of metallurgical friends and assistants, during the last few years devoted much time in endeavouring to clear away the fog which surrounds the subject by studying with the aid of the microscope and chemical analysis. The results have far exceeded anticipation, but there still remains much to be done; and it is sincerely wished that metallurgical students will not only repeat the

* The small figures coincide with the index numbers of the Bibliography in Appendix V.

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CLASS I.

Phosphorus from traces to about 1·70 per cent.

The preliminary examination of a few samples containing between 1 per cent. and 2 per cent. phosphorus clearly showed in the latter two distinct constituents, one consisting of crystalline grains, the other of a hard constituent enveloping the grains, closely resembling carbide of iron or cementite.

The samples containing between 1 per cent. and 1·4 per cent. were quite free from the hard constituent. It thus became clear that in iron containing between 1·4 per cent. and 2 per cent. phosphorus there must exist a critical point.

After making many "melts" and careful micro-examinations of the specimens prepared, one of the small masses of metal, which had been allowed to cool *very slowly* in the crucible, on sectioning and inspection, was found to be free from the hard constituent near the outside, but contained much of it in the central portions. The exterior part was cut off and carefully analysed, with the following result:—

	Per Cent.
Carbon	0·02
Silicon	trace
Sulphur	0·03
Phosphorus	1·63
Manganese	trace

Valuable data was also obtained from a very crystalline piece of metal which was found lodged between the bricks in a puddling furnace, and was taken out when the furnace was off for repairs.

The crystalline particles were arranged in columnar form, which averaged about one inch in length. The macrostructure had much the same appearance, on a small scale, of the basaltic formation at Staffa. Fracture was readily effected along the columnar junctions. Each complete column constituted a single allotriomorphic crystal, and its external form had no relation to the orientation or cleavages, which were different in each parallel column. They were quite free from carbon, silicon, and manganese.

On examination of sections made vertically and horizontally through the columnar masses, the columns were found to be enveloped by the hard constituent above referred to.

The object of this more rapid cooling was to ascertain whether or not more phosphide, under such conditions, would be left in the crystalline mass. The analysis of the metal was as follows:—

	Per Cent.
Iron	97.35
Carbon	0.02
Manganese	Nil.
Silicon	Nil.
Phosphorus	1.94
Oxygen, &c.	0.69
	<hr/>
	100.00
Phosphorus in free phosphide	0.19
Phosphorus in the crystalline mass	1.75

It is apparent, then, that iron will retain, at its solidifying point, between 1.63 per cent. and 1.75 per cent. phosphorus, the amount varying slightly according as the passage from the liquid to the solid state is rapid or retarded.

Under normal conditions of cooling, in which the molten metal is withdrawn from the fire and allowed to solidify in the crucible, it may be accepted that 1.70 per cent. phosphorus will be retained in the crystalline mass, and that any of the element exceeding 1.70 per cent. will fall out of solution in the definite compound Fe_3P , which will then form cell walls to the crystalline grains or irregular-shaped eutectic* masses distributed throughout the metal.

Judging from the variable amount of phosphide retained by the iron at its solidifying point, and the ease with which some of what is so retained can be thrown out of solid solution,† proof of which will be given later, I am justified in concluding that all the crystalline compounds containing no free phosphide of iron (triferrous phosphide) are solid solutions in iron, not of phosphorus, but of the definite chemical compound Fe_3P .

On the Action of Reagents on the Metals of Class I.

Metals containing between 0.10 per cent. and 1.70 per cent. phosphorus leave a black residue on treatment with dilute hydrochloric acid or sulphuric acid. The amount of the insoluble residue increases with the phosphorus. The less the phosphorus the slower is the action of the acid.

* Notes on eutectics will be found in Appendix I.

† Notes on solid solutions will be found in Appendix II.

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the acid for two weeks, the other for four days. The atomic ratio of the iron and phosphorus in the black residue was as follows :—

1st sample, treated with acid for 14 days = $\text{FeP}_{1.75}$

2nd sample, treated with acid for 4 days = $\text{FeP}_{1.30}$

The fact that the long-continued action of hydrochloric acid on Fe_3P leaves a black non-magnetic residue similar, as regards the ratio of the iron to phosphorus, to the residues from iron and phosphorus compounds containing no free phosphide, is strong evidence in proof that such compounds are solidified solutions of phosphide of iron in iron.

There can be no doubt that the residues in both cases are decomposition products, and are not definite chemical compounds.

The property of spontaneous combustion at 80°C . may possibly be due to the presence of one of the higher hydrides of phosphorus.

The study of these residues is a research in itself, and one which must be carefully followed before we can feel justified in forming definite conclusions.

On etching together in dilute acids polished pieces of iron or steel containing varying proportions of phosphorus, they darken relatively with the proportion of phosphorus present. Taking advantage of this observation, I have found it valuable in detecting the segregation of phosphorus in soft steel bars; for where there was most phosphorus the ferrite darkened relatively more rapidly (on the continued acid of dilute acid) than did the ferrite in the portion external to the segregate.

An instance of this has quite recently come under my notice. A test-piece cut from a gun-forging, on etching, darkened relatively more rapidly in one part than in the greater mass of the section. On drilling out the dark and light portions and subjecting them to chemical analysis, the phosphorus was found to be 0.12 per cent. in the dark portion, whilst the light part contained only 0.03 per cent. As the bar failed to stand the regulation test entirely owing to the segregation, it is reasonable to conclude that if a steel shaft, or other structure which has been turned up at one end in a lathe and roughly polished on ordinary fine emery paper, were to be placed in, or washed by, dilute acid for a minute or two, such segregation would be at once detected. I have actually tested many samples in this way, and

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Works. They were taken from a charge of metal in a basic-lined converter during the after-blow. The small ingots were much honeycombed, but, for all that, a sufficient quantity of clean drillings was obtained from each upon which to experiment. In each case one gramme of drillings was used. They were dissolved under different conditions. One set was dissolved in strong concentrated hydrochloric acid, using 20 c.c. of acid. Solution was accelerated by heating. When dissolved, the solutions were just brought to the boiling-point. They were then oxidised with nitric acid, well boiled, and finally the phosphorus remaining in the solution was gravimetrically determined.

In a second series the same treatment was followed, with the exception that the acid was diluted with an equal volume of water.

In a third series the treatment was the same as in the second, excepting that solution was allowed to take place in the cold.

The total phosphorus having been determined in each case, the difference between that obtained by the special treatment and the total was accepted as that portion which had passed off as gas. This method was much easier to work than that of Osmond and Jüptner, and had the advantage that a large number of assays could be made simultaneously.

The results obtained were as follows:—

Analyses of Samples.

	1.	2.	3.	4.	5.
	Per Cent.	Per Cent.	Per Cent.	Per Cent.	Per Cent.
Iron	97.80	98.20	98.70	98.90	99.60
Carbon	0.06	0.05	0.05	0.04	0.04
Phosphorus	1.69	1.32	0.62	0.23	0.065
Not determined	0.45	0.43	0.63	0.83	0.295
	100.00	100.00	100.00	100.00	100.00
<i>Dissolved in strong hot acid, 1 grm. iron to 20 c.c. HCl.</i>					
Phosphorus evolved as PH_3	0.26	0.42	0.30	0.17	0.052
Phosphorus in residue	1.33	0.91	0.32	0.06	0.016
Per cent. gasified	15.00	31.00	48.00	74.00	80.000
<i>Dissolved in weak hot acid.</i>					
Phosphorus evolved as PH_3	0.28	0.26	0.14	0.11	0.028
Phosphorus in residue	1.41	1.06	0.48	0.12	0.037
Per cent. gasified	16.00	20.00	23.5	48.00	74.000
<i>Dissolved in weak cold acid.</i>					
Phosphorus evolved as PH_3	0.06	0.09	0.07	0.11	0.035
Phosphorus in residue	1.63	1.23	0.55	0.12	0.030
Per cent. gasified	3.5	6.5	11.00	48.00	54.000

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to account for the phenomena. A probable explanation is that the more attenuated the phosphide, and the greater the proportion of iron, and the more nascent hydrogen available, the more readily the phosphide will be decomposed and hydrogenised.

Certain results of Baron Jüptner, referred to subsequently, do not appear to confirm such a view; it is therefore necessary to await the results of further research before we can form other than tentative conclusions, seems to point in the direction that the more diffused the phosphorus, and the greater the proportion of phosphine formed, the safer the steel.

This question, however, will be further discussed in Part II., when the influence of carbon is considered.

When nitric acid of specific gravity 1.42 is poured upon iron containing little phosphorus, the iron becomes passive, and will not dissolve until the solution is heated; but when the percentage of phosphorus is high, say between 0.6 per cent. and 1.7 per cent., the passivity disappears and the acid attacks the metal violently.

In very dilute solutions its action resembles that of sulphuric and hydrochloric acids, ferrous nitrate and the black decomposition product being formed.

With nitric acid of specific gravity 1.20, and at a temperature of about 20° C., a perfectly clear solution results, free from any black decomposition product, whilst under like conditions free phosphide of iron, Fe_3P , is but little acted upon. This reagent then is a very good one for separating free phosphide from phosphide of iron in solid solution. Practically all the results showing the amount of free phosphide of iron given in this paper were obtained by a method based upon this behaviour of nitric acid. Details of the method are given in Appendix III.

The Effect of Annealing Iron saturated with Phosphide of Iron.

The next question which arose was, will phosphide of iron separate from the solid saturated compound containing above 1.8 per cent. of phosphorus by annealing and slow cooling?

To answer this, a large piece of metal, containing about 1.8 per

1. The first step is to identify the problem or question that needs to be answered. This involves understanding the context and the specific requirements of the task.

Abstract

[illegible]

Figure 1. The effect of the concentration of the *Agrobacterium* suspension on the transformation efficiency of *Agrobacterium* strains. The number of transformed cells was determined by the number of colonies obtained on the selective medium. The results are the mean of three independent experiments. Error bars represent the standard deviation.

2. The Commission has received information from the Government of the Republic of the Philippines that the Philippine National Police (PNP) has been instructed to investigate the alleged human rights violations committed by its personnel during the period of the Marcos regime. The Commission is aware that the PNP has been instructed to investigate the alleged human rights violations committed by its personnel during the period of the Marcos regime.

SECRET

[illegible]

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1. The first group of people who are interested in the study of the history of the United States are the people who are interested in the history of the United States.

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1. The first step in the process is to identify the problem or issue that needs to be addressed. This involves gathering information and understanding the context of the problem.

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The outside layer was very spongy and porous, and contained oxide of iron in considerable quantity.

In this layer it was noticed, on micro-examination, that the areas which had been originally filled with phosphide eutectic were quite empty. It had evidently run out, and had been absorbed in the spongy oxide surrounding it, leaving cavities of the characteristic shape shown in Photo No. 8. In no other parts excepting these could the cavities be detected.

It is probable that the figure 1·35 per cent. does not correctly represent the phosphide held in the iron, as some of it was no doubt in the state of phosphoric acid. The other analyses made on the solid and non-oxidised material indicate beyond doubt that, on long annealing the metal saturated with phosphide at its solidifying point, a portion of that substance separates out, leaving the mass with only about 1 per cent. phosphorus.

This most interesting experiment disposes of the conception that the solid solution at the solidifying point, containing about 1·70 per cent. phosphorus, is a definite chemical compound.

In order to ascertain whether a portion of what separated on annealing at about 900° C. would recombine at 1100° and 1300°, and after melting, portions of the annealed metals were heated for half-an-hour at these temperatures, and a third portion was melted in a magnesia crucible. They were then cooled and analysed. The following were the results obtained:—

	Heated to 1100° C.	Heated to 1300° C.	Melted.
	Per Cent.	Per Cent.	Per Cent.
Phosphorus in free phosphide . . .	0·95	0·91	0·20
Phosphorus in solid solution . . .	1·01	1·06	1·74
	1·96	1·97	1·94

They show clearly enough that even at 1300° C., a point not far removed from the point of fusion, practically no phosphide was reabsorbed.

Microscopic Examination of the Annealed Metal.

A section of the metal before annealing and decarburising is represented in Photo No. 8, in which it will be seen the

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Physical Properties.

The peculiar property of brittleness which phosphorus gives iron is well known, and it is the universal opinion that that element is the most objectionable of all the metalloids which enter into the composition of steel and iron.

Various observers do not agree exactly as to the effect of phosphorus on the physical properties. ⁽¹⁹⁾ Professor Howe, in his work on "The Metallurgy of Steel," gives a condensed account of the results obtained by many observers, and forms the following conclusions:—

"1st. We may infer that when the phosphorus is above, say, 0.12 per cent., it probably has no important constant effect, for if it had, the analysis of statistics should yield concordant results.

"2nd. Phosphorus usually raises the elastic limit, and thus the elastic ratio, an index of brittleness; indeed, the elastic limit and breaking strength of steel occasionally coincide."

The whole question as to the effect of phosphorus requires to be reinvestigated, and such investigations must not be confined to chemical analyses and mechanical behaviour in the testing-machine, but should include the character of the microstructure, and more particularly the orientation and size of the crystalline grains.

The great variations in the mechanical properties of phosphoretic steels containing approximately the same amount of phosphorus most probably is caused by difference in structure. I have myself obtained widely different results from the same high phosphorus steel by treating it so as to obtain such variations.

⁽⁸⁾ Professor Arnold has given the results on examining iron containing 1.37 per cent. phosphorus and 0.07 per cent. carbon.

Such iron may be considered as nearly saturated with phosphide of iron, and to have the following constitutional analysis:—

	Per Cent.
Iron	90.16
Phosphide of iron in solid solution	8.79
Carbide of iron	1.05
	<hr/> 100.00

It was drilled and turned with difficulty. On etching, the

Crystalline Form.

The crystalline structure of irons containing much phosphorus is apparently the same as pure iron. In the drusy cavities of ingots of each there are to be found the fir-tree growths of crystallites of the cubic system. It does not appear that the dissolved phosphide modifies the crystalline form, but possibly when perfectly measurable crystals are isolated, if they ever are, it will be found that the phosphide does cause some slight variation. It is easy to obtain rectangular forms by cleavage from large crystalline grains of iron saturated with phosphide.

There is an increasing tendency, under like conditions of treatment with increasing phosphorus, for iron to crystallise in larger and larger crystalline grains, and I have frequently obtained in fractured metals containing above 1 per cent. phosphorus cleavage faces measuring more than an inch across.

Mr. T. W. Sorby, of Sheffield, very kindly annealed for me, in one of his cementation furnaces, a portion of a metal containing 1.15 per cent. phosphorus. The coarsely crystalline metal was inserted and packed with sand in an iron tube which was closed at both ends with fine clay.

The temperature to which it was subjected must have been about 1000°C. , and it was maintained at that temperature for a considerable period. When cold, the appearance was found not to have altered, and, on breaking it to pieces and selecting such external portions as had, in fracturing the metal previous to annealing, broken along three cleavages, leaving corners in projection bounded by three cleavage faces, it was found that, on breaking these, cleavage followed the planes parallel to the faces, proving that the crystalline organisation had not been altered by the prolonged heating, and that there had therefore been no allotropic change to the gamma state.

Hardness.

The hardness of iron is steadily increased with each addition of phosphorus, until, when it is saturated, and contains 1.7 per cent. phosphorus as phosphide, it takes a well-hardened steel drill to drill it properly, and it apparently has a hardness on Mohr's scale of just under 6, probably 5.50; a sharp

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reaction which did not follow when the black deposit was formed by etching hardened pure carbon steels. It evidently consisted of the same substance which is left insoluble on dissolving the metals in acid.

CLASS II.

Phosphorus 1.70 per cent. to 10.2 per cent.

In the compounds containing a little over 1.70 phosphorus, the eutectic or pearly constituent, being last to freeze or solidify, is thrown out or expelled from the crystalline grains, and forms fluid boundaries or cells round about them. As the temperature falls these finally solidify, breaking up into two constituents. When cold the polished and etched structure, under low power magnification, has the appearance of an irregular meshed net, the spaces being filled with that part of the crystalline grains of metal which first solidified.

The metal with 1.8 per cent. phosphorus (represented in No. 2 photograph) is an example of this, and somewhat resembles steel containing $1\frac{1}{2}$ per cent. carbon.

When the phosphorus approaches 8 per cent. a pearly constituent occupies the greater area, and on this ground mass skeleton arboriform crystallites abound, consisting of the saturated solid solution of phosphide of iron in iron. (No. 3 photograph represents this compound.)

As 10.2 per cent. is approached these crystallites diminish, and when it is reached the whole mass or area is pearl-like in structure and no crystals are visible. (Photo No. 4.)

All the eutectics of the metallic alloys have not the same appearance or form, but most of those I have examined (and I have examined a very large number) had one common property—that of giving the pearly structure, first discovered by Dr. Sorby in carbon steels after they had been polished and etched by suitable reagents.

The pearly mass with about 10 per cent. phosphorus and 90 per cent. iron is the true eutectic, or the most fusible of the compounds of iron and phosphorus. It has only one melting-point, which is about 980° C.

The melting-points in the metals of Class I. steadily fall with

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prove that the crystals are a definite chemical compound, of the formula Fe_3P .

The metal sections containing the well-formed crystals of Fe_3P have been kindly examined for me by Professor Bauerman, Professor Arnold, and Mr. MacWilliam, who consider that they will most likely prove to be rhombic or oblique.

So far only the *sections of the crystals* have been available for examination, but it is hoped that before long they will be isolated so as to enable the angles to be correctly measured.

In my paper on "The Crystalline Structure of Iron," I gave a photograph of what was believed to be an idiomorphic crystal of carbide of iron.

The metal section photographed contained phosphorus. On re-examination by the heat-tinting process, I found that the crystals believed to be carbide were not so, but were phosphide of iron. I am glad of this opportunity of correcting an erroneous conclusion which any one might have made previous to the discoveries of the method of distinguishing one from the other. Other metallographers would probably find, on re-examining their specimens by the new method, that what they had taken to be cementite was in reality phosphide of iron.

CLASS IV.

Phosphorus between 15·58 per cent. and 21·68 per cent.

When the phosphorus is increased above 15·58 per cent. somewhat porous ingots result, and until 21·68 per cent. is present it is easy to separate the powdered metal into two distinct parts.

On endeavouring to colour or stain the constituents of polished sections so as to identify them by the usual etching methods, no success followed the effort; but on heating them till a blue oxidation temper tint was just visible to the eye, on examination under the microscope two differently coloured parts became evident, one blue, more readily oxidised than the other, and a second which appeared yellow.

Both constituents were practically homogeneous, and were evidently definite chemical compounds. One of these compounds was less soluble in nitro-hydrochloric acid than the other. The more insoluble part was also least readily attracted by the magnet.

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It is not often that compounds can be separated by such simple and diverse methods:—

- 1st. By chemical reagents.
- 2nd. By the magnet.
- 3rd. By heat-colouring and by hand-separation.

Of the three, the magnetic method is by far the most perfect, for whereas Fe_2P is strongly attracted, Fe_3P will not rise to the magnet, and only slightly adheres to it when placed in contact with the finest powder.

CLASS V.

Phosphorus 21·68 per cent. to 24 per cent.

By the expenditure of a very excessive amount of phosphorus and the use of a very high temperature, iron may be made to combine directly with sufficient phosphorus to give a compound containing 24 per cent. of that element. This is contrary to what was found in Dr. Percy's laboratory, where a maximum of 8·46 per cent. was obtained by that method. It is nevertheless an undoubted fact that the higher phosphide can be obtained by direct union.

On polishing the compound so obtained and tinting it by heating, the microscope revealed the presence of two differently coloured constituents. The more easily oxidised was undoubtedly the definite compound Fe_3P , but what the second was has not yet been determined.

SUMMARY OF PART I.

Class I.—Phosphorus, traces to 1·7 per cent.—The metals of this class consist of iron containing phosphide of iron, Fe_3P , in solidified solution.

All the metals used commercially, such as wrought iron and steels containing practically no carbon, may be included in this class.

In proportion as the phosphorus is increased, the polished and etched specimens under like acid etching darken relatively with the quantity of phosphorus present.

the first of these is the fact that the system is not self-sufficient. It is not possible to produce all the goods and services that are needed for the system to function. This is because the system is based on a division of labor, and each individual is specialized in a particular task. As a result, the system is dependent on the cooperation of all individuals in order to function properly. This is a major weakness of the system, and it is one of the reasons why it is not widely adopted.

The second major weakness of the system is the fact that it is not flexible. The system is based on a fixed set of rules and regulations, and it is not possible to change these rules and regulations without the approval of the entire system. This is a major weakness of the system, and it is one of the reasons why it is not widely adopted.

The third major weakness of the system is the fact that it is not efficient. The system is based on a complex set of rules and regulations, and it is not possible to simplify these rules and regulations without the approval of the entire system. This is a major weakness of the system, and it is one of the reasons why it is not widely adopted.

The fourth major weakness of the system is the fact that it is not scalable. The system is based on a fixed set of rules and regulations, and it is not possible to change these rules and regulations without the approval of the entire system. This is a major weakness of the system, and it is one of the reasons why it is not widely adopted.

The fifth major weakness of the system is the fact that it is not secure. The system is based on a fixed set of rules and regulations, and it is not possible to change these rules and regulations without the approval of the entire system. This is a major weakness of the system, and it is one of the reasons why it is not widely adopted.

The sixth major weakness of the system is the fact that it is not transparent. The system is based on a fixed set of rules and regulations, and it is not possible to change these rules and regulations without the approval of the entire system. This is a major weakness of the system, and it is one of the reasons why it is not widely adopted.

The seventh major weakness of the system is the fact that it is not accountable. The system is based on a fixed set of rules and regulations, and it is not possible to change these rules and regulations without the approval of the entire system. This is a major weakness of the system, and it is one of the reasons why it is not widely adopted.

The eighth major weakness of the system is the fact that it is not sustainable. The system is based on a fixed set of rules and regulations, and it is not possible to change these rules and regulations without the approval of the entire system. This is a major weakness of the system, and it is one of the reasons why it is not widely adopted.

The ninth major weakness of the system is the fact that it is not inclusive. The system is based on a fixed set of rules and regulations, and it is not possible to change these rules and regulations without the approval of the entire system. This is a major weakness of the system, and it is one of the reasons why it is not widely adopted.

The tenth major weakness of the system is the fact that it is not innovative. The system is based on a fixed set of rules and regulations, and it is not possible to change these rules and regulations without the approval of the entire system. This is a major weakness of the system, and it is one of the reasons why it is not widely adopted.

rounded by the eutectic containing about 10·2 per cent. phosphorus. (Photos Nos. 5 and 6.)

Class IV.—Phosphorus 15·58 per cent. to 21·68 per cent.—In the slowly cooled compounds of this class we commence with pure Fe_3P and end with Fe_2P . The intermediate compounds consist of mixtures of the two bodies, easily separated from each other when in powder by a magnet. Fe_3P is readily attracted, Fe_2P very slightly so.

Class V.—Phosphorus 21·68 per cent. to 24 per cent.—This class has not been sufficiently studied, but it contains two constituents, one of which is Fe_2P .

PART II.

INFLUENCE OF CARBON ON IRON CONTAINING PHOSPHORUS WHEN MELTED TOGETHER.

The study of simple binary compounds is comparatively easy compared with the research relating to compounds containing three or more elements, and in giving the results of a large number of experiments with compounds of iron with carbon and phosphorus, I do not wish it to be supposed that the research has been more than just commenced.

In studying the compounds containing both separated massive carbide and phosphide of iron, existing as they often do side by side, it has been found that the etching methods will not develop indications sufficient to enable the microscopist to tell one from the other. Mr. Osmond and I have independently discovered that the very beautiful method, employed first by Professors Behrens and Martens, which consists of simply heating the polished metals till they are more or less coloured by oxidation, enabled them to do so.* Carbide of iron on heating takes the oxidation tints of straw-yellow, yellow, brown, red, purple, blue, and silver-grey in sequential order. Phosphide of iron passes through the several ranges of colour, but not so rapidly as the carbide.

When a piece of metal which contains carbide and phosphide of iron is heated (by placing it on an iron plate which is heated

* See Appendix IV.

carbon. When the carbon is small, the phosphorus eutectic is found at the junctions of the grains more or less completely enveloping them, and surrounding it the pearlite forms most perfect fringes, well illustrated in the two photographs (Nos. 8 and 9), where 1.75 per cent. phosphorus is associated with 0.125 per cent. carbon. With 0.7 per cent. carbon the mass of the grains consists of pearlite, but there still exist areas of the phosphide saturated solid solution. (Photo No. 10.)

As the carbon increases, the amount of the phosphorus eutectic and the pearlite also increase in quantity, until, when about 0.8 per cent. carbon is present, the grains consist entirely of pearlite.

When the carbon is increased to 1.4 per cent. the eutectic of phosphide becomes surrounded by a solid layer of cementite or carbide of iron, which increases in thickness as the carbon is increased. The envelopes of carbide are solid and do not consist of two constituents, whereas the enclosed matter has the usual broken-up duplex character of a eutectic. The white carbide and phosphide appear to run into one another.

When a section of the metal was heated till the eutectic assumed a yellow tint, the cementite borders assumed a fine red colour; it was easy then to see that the carbide was separate from the phosphide at a most clearly marked junction. (Photo No. 11.)

On re-heating it to about 900° C., and allowing it to cool moderately rapidly, the greater mass of cementite was found no longer as an envelope to the phosphide eutectic areas, but now existed as independent cells, cutting up the original large grains of pearlite into a number of smaller grains. The phosphide eutectic retained its original position.

This observation appears to demonstrate that whereas the phosphide eutectic does not diffuse at 900° C., the carbide passes into solid solution at that temperature, and is, on cooling, redistributed between the newly formed pearlite grains. In other words, it behaves in a similar manner to what it does in high carbon steels free from phosphorus. The eutectic, although retaining its original position at 900° C., undoubtedly must have become liquid, for it had altered its character; the two constituents were in a much finer state, and required much higher magnification to see that they were separate.

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exact composition has not yet been determined. A sufficient quantity of the compound free from other elements, such as silicon, manganese, &c., was difficult to obtain, on which to squeeze out the eutectic by hydraulic pressure.

A small quantity of metal yielded a fusible liquate of the following composition, viz. :—

	Per Cent.
Phosphorus	7.05
Carbon	1.30
Iron	91.60
	<hr/>
	99.90

This was not pure, and is only given here as representing the approximate composition of the eutectic.

The Effect of Carbon on Iron containing less than the Saturation Proportion of Phosphide Phosphorus when melted together.

When the phosphorus is in much smaller quantity than 1.7 per cent., if the carbon is in sufficient quantity it still causes a separation of phosphide.

An excellent example of this has been afforded by Mr. E. H. Saniter, who discovered in the hearth of an open-hearth basic furnace a piece of partially converted metal which had remained in the bed of the furnace when it was cooled down for relining.

An analysis of this metal yielded in my laboratory :—

	Per Cent.
Carbon (by combustion)	1.230
Manganese	0.450
Silicon	0.060
Sulphur	0.018
Phosphorus	1.380

A portion broken off from the same material yielded the following result by Mr. Saniter's analysis :—

	Per Cent.
Carbon	0.360
Manganese	0.420
Silicon	0.055
Sulphur	0.018
Phosphorus	0.340

These analyses are far from concordant, and are evidence of the great difficulty of obtaining two pieces alike from a mass of metal

the first of these is the fact that the system is not a simple one.

It is a complex one, and it is one that is not easily understood.

It is a system that is not easily understood, and it is one that is not easily understood.

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inclusions of pearlite were present, consisted mainly of phosphide of iron. (Photo No. 13.)

If the mass had been cooled less slowly, there can be no doubt the central portion of the envelopes would have shown the compound structure of the eutectic of phosphorus and iron; but, as is very common in alloys, when the actual mass of the eutectic is small and the cooling very slow, the harder constituent had coalesced or segregated and become massive, whilst the softer portion had been thrown out and united with the greater mass of the surrounding metal.

When this specimen was heated to 900°C ., and was allowed to cool in a few minutes from that temperature to 500°C ., the envelopes in the polished and tinted section were seen under the microscope to have the true eutectic structure. They were considerably thicker, and occupied more space than the original phosphide areas. The eutectic so formed resembled that in white phosphoretic pig metals.

This complex eutectic is what is always found in white cast iron containing phosphorus.

On breaking a section of the original metal, which had been previously polished and tinted, the line of fracture passed along the phosphide, in the centre of the cell walls.

Mr. Saniter, previous to the systematic micro-study referred to, when he was chemist to the Wigan Coal and Iron Company, having microscopically examined the specimen, and having found that the cell walls were considerably thicker than was justifiable with so little carbon as 0.98 per cent., and knowing that the envelope was much more brittle than the body of the grains of pearlite, he endeavoured, by crushing and sieving, to separate the more easily powdered envelope from the greater bulk of pearlite. Of course, such a crude mechanical process could not be expected to give perfect separation, but, with the assistance of chemical methods in addition, he obtained some most valuable results.

By Mr. Saniter's permission his original results are here given in his own words:—

"As was anticipated on examination under the microscope, it was evident that brittleness was caused by the segregation of a hard substance with the appearance of cementite along the granular junctions. With a view to ascertain its composition

1. The first part of the paper is devoted to a general discussion of the problem of the existence of a solution of the system of equations (1) for arbitrary values of the parameters α and β . It is shown that the system of equations (1) has a solution for arbitrary values of the parameters α and β if and only if the condition

$$\alpha + \beta = 1$$

is satisfied. In the case when the condition (2) is not satisfied, the system of equations (1) has no solution.

2.

3.

4. The second part of the paper is devoted to a detailed analysis of the properties of the solution of the system of equations (1) for arbitrary values of the parameters α and β . It is shown that the solution of the system of equations (1) is unique and that it depends continuously on the parameters α and β . It is also shown that the solution of the system of equations (1) is bounded and that it attains its maximum and minimum values on the boundary of the domain of definition.

5. The third part of the paper is devoted to a study of the asymptotic properties of the solution of the system of equations (1) for large values of the parameters α and β . It is shown that the solution of the system of equations (1) tends to zero as the parameters α and β tend to infinity.

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8. The fourth part of the paper is devoted to a study of the properties of the solution of the system of equations (1) for small values of the parameters α and β . It is shown that the solution of the system of equations (1) tends to infinity as the parameters α and β tend to zero.

"If we examine the eutectic containing 0·64 per cent. carbon and 0·62 per cent. phosphorus, we find that, after allowing for iron to carbon in the ratio Fe_{24}C , the composition of ordinary pearlite, the remaining iron is in the ratio Fe_{22}P , a figure very interesting, as it is so close to that for the carbon eutectic. This may be only a coincidence, and it would require a considerable amount of investigation before it could be determined whether or not phosphorus forms a similar eutectic to that of carbon with iron. Calculating on these lines, the pearlite grains consist of—

		Per Cent.
Fe_{24}C	:	71·11
Fe_{22}P	:	28·77 with a formula $2\cdot6 \text{Fe}_{24}\text{C}, \text{Fe}_{22}\text{P}$."

These results of Mr. Saniter, obtained some years before my researches were completed, coincide closely with those obtained at Middlesbrough. The very low carbon, however, which he found in the finely powdered residue may be due to the fact that some of the comparatively coarse carbide plates of the pearlite escaped the sieve.

It is possible that, when there is a considerable quantity of phosphorus present, the pearlite may contain about 0·6 per cent. phosphorus, and the smaller proportion found dissolved in the compound containing 3·5 per cent. carbon given on p. 87 may be owing to the pearlite present representing only about 41 per cent. of the mass.

If the carbon in the pearlite is 0·75 per cent., and that in the massive cementite 6·666 per cent., by calculation the sample with 3·5 per cent. carbon should have the following constitutional analysis:—

	Per Cent.		Carbon per Cent.	Phosphorus per Cent.
Carbide of iron (massive)	48 × ·0666	=	3·19	...
Pearlite	41 × ·0075	=	0·30	...
Phosphide of iron (free)	9 × ·1556	=	...	1·40
" " (dissolved)	2 × ·1556	=	...	0·31
	100·00		3·49	1·71

The pearlite would in such a case contain 0·75 per cent. instead of 0·60 per cent. of phosphorus. If, however, we remember that in one case the metal was cooled very much slower than the other, it may account for the difference.

It is satisfactory in so far as the calculation gives about the same amount of dissolved phosphide as was actually found in the

falling together as the supporting cells flowed away, united to form a homogeneous whole. The micro sections in this case showed no empty spaces; no cementite or phosphide enveloped the grains; but on polishing on parchment, broad reticulated bands, corresponding to the original positions of the cells, remained bright long after the intercell structure had become tarnished, showing the existence of parts more highly charged with phosphorus in the regions where the free phosphide had originally existed. Etching with acid and heat oxidation all confirmed that conclusion. It is evident, then, that some of the phosphide had diffused into the grains, but had not penetrated to any great distance. The amount actually so diffused is shown by the analysis to be 0.11 per cent. In one or two parts of the section comparatively large solidified "pools" of the eutectic were located, thus accounting for the free phosphide found by analysis. The same pools or areas of massive segregations were present in the original metal and were generally located at the junctions of several grains, and it appears reasonable to conclude that the surrounding metal under such conditions could not fall in and join together, and so force out the liquid eutectic; it would, therefore, remain imprisoned at the very time during which the portions of the eutectic between the granular faces were flowing out of the metal.

If, then, the eutectic was actually expelled, it should be found in the scale in which the metal was packed. Fortunately a portion of this had been reserved. It was tested together with a portion of the scale before it was packed in the tube. The following results were obtained:—

	Before.	After.
	Per Cent.	Per Cent.
Iron	74.6	96.3
Phosphorus	0.06	0.24

The quantity actually used was considerable. No record was kept of the relative weights of the metal and scale, so that it is impossible to make a balanced account of the phosphorus.

The fact, however, that the phosphorus in the scale was greatly increased is strong proof that it had obtained it from the metal.

One other interesting observation was made on the sample. It was noted that the metal immediately adjoining the scale, 1 m.m. in thickness, behaved under the action of acids almost

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ANALYSES OF METALS.

	Carbon.	Phosphorus.
No. 1	1.05	0.020
No. 2	1.06	0.068
No. 3	1.05	0.118
No. 4	1.06	0.245

MICRO-STRUCTURE.

No. 1 was slightly meshed with cementite, but no phosphide could be detected.

No. 2 was more meshed than the last, and phosphide of iron was visible after heat-tinting.

No. 3 was more meshed than the last, and a greater proportion of phosphide was visible.

No. 4 had phosphide in strong evidence.

Although the phosphide was in strong evidence judging from the appearance, only a very small proportion of the whole seemed to be in the free state. In the case of No. 4, if all had separated there would have been about 3 per cent. of the eutectic visible, whereas probably not more than one-third of that amount was really present. A further trial was made on a larger scale, but in this case a charge of about 50 lbs. of molten steel was poured successively into five different small fireclay moulds. After the first mould was filled a stick of phosphorus was dropped into the fluid steel in the crucible, where it rapidly dissolved. After mixing a second mould was filled. A second stick of phosphorus was then added to the crucible and a third mould filled. After each mould was filled a further addition of phosphorus was made to the remaining steel till all the five moulds were filled.

The analyses of the steels when cold were as follows:—

No.	Carbon.	Phosphorus.	Phosphorus in Free Phosphide.
	Per Cent.	Per Cent.	Per Cent.
1	0.96	0.037	Nil
2	0.96	0.099	0.002
3	0.95	0.122	0.035
4	0.96	0.347	0.065
5	1.02	0.548	0.163

No free phosphide could be detected by the microscope in No. 1. In No. 2 it was doubtful if any was present. No. 3

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the carbon causes the phosphide to be concentrated either in the massive ferrite or in the ferrite of the pearlite, or in both.

Before discussing this question, reference must be made to the valuable results given by (¹⁴) Messrs. Osmond and Werth.* These gentlemen, on treating various metals, irons, and steels with hydrochloric acid under the same conditions, found that the proportion of the phosphorus given off as phosphine gas (PH_3) varied with the amount of carbon present. I cannot do better than give a short abstract from their most valuable paper. The phosphine evolved was absorbed in an ammoniacal solution of silver nitrate.

"We have determined the quantity of Ag reduced, *i.e.* the proportion of PH_3 evolved by a series of very different products, passing the gas first through an ammoniacal solution of CdSO_4 , where H_2S is absorbed.

"Appended are the results obtained on dissolving 4 grammes of each metal in 35 c.c. concentrated hydrochloric acid and gradually heated until completely attacked:—

Material.	Analysis.					P. Evolved as PH_3 per 100 Samples.	Parts per 100 P. as PH_3 .
	C.	Mn.	Si.	T.	P.		
	Per Cent.	Per Cent.	Per Cent.	Per Cent.	Per Cent.	Per Cent.	Per Cent.
<i>Acid Bessemer Steel—</i>							
Before the addition of spie- geleisen . . . . . }	...	...	...	...	0.065	0.044	68
After such addition . . . . . }	...	...	...	...	0.065	0.028	43
<i>Basic Bessemer Steel—</i>							
Before the addition of spie- geleisen . . . . . }	...	...	...	0.038	0.046	0.030	65
After such addition . . . . . }	...	...	...	0.022	0.046	0.018	39
<i>Open-hearth Steel—</i>							
Before the addition of spie- geleisen . . . . . }	...	...	...	...	0.033	0.022	67
After such addition }	0.49	0.37	0.075	0.024	0.041	0.014	34
Hardened }	0.49	0.37	0.075	0.024	0.041	0.013	32
Very soft steel }	0.18	0.10	...	0.060	0.070	0.049	70
"Diamond" steel No. I. }	1.17	0.18	0.44	0.018	0.033	0.005	15
Ordinary Bessemer steel }	0.50	0.57	0.11	0.042	0.065	0.030	46
Ordinary Bessemer steel }	0.49	0.74	0.23	0.022	0.065	0.026	40
Pig iron . . . . . }	...	...	...	...	0.055	0.041	38
Burnt iron from the Moselle, in pseudo-crystals }	0.11	trace	0.058	0.032	0.810	0.147	18
Spiegeleisen }	4.00	19.84	...	...	0.145	0.004	3
Basic Bessemer pig iron }	3.00	2.16	1.71	0.13	2.500	0.037	1.5
Forge pig iron }	3.00	0.07	1.37	0.48	1.750	0.038	2.2

* *Theorie Cellulaire*, Mem. de l'Artillerie de la Marine, 1887, vol. ii. p. 273.

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the state of PH_3 , and on the other hand from steels low in carbon the preponderating proportion of the phosphorus passed off as that gas on dissolving them in strong hydrochloric acid.

Baron Jüptner also, in his researches, shows that in high carbon metals only a very small proportion of the total phosphorus passes off as PH_3 . He does not, however, appear to have examined steels with more than 0.30 per cent. carbon.

The following table gives Baron Jüptner's results, and in addition the percentage proportion of phosphorus given off as PH_3 , which I have calculated from them, viz. :—

No.	Carbon per Cent. by Weight.	Phosphorus per Cent. by Weight.	Phosphorus per Cent.		Remarks.
			Parts per 100 Sample, as PH_3 .	Parts per 100 P, as PH_3 .	
1	2.385	0.1315	0.0263	2.00	A. Pig iron.
2	3.418	0.0744	0.0026	3.5	White pig iron.
3	3.418	0.0744	0.0058	7.8	Dark grey pig.
					Dark grey pig, dissolved in sulphuric acid diluted with equal volume of water.
4	2.296	1.048	0.0383	3.6	So-called "Panseergus" for fire-bars.
5	0.2254	0.0970	0.0054	5.50	B. Wrought iron and steel.
6	0.1800	0.0596	0.0020	3.30	Short.
7	0.1510	0.0690	0.0012	1.71	Short.
8	0.239	0.1010	...	...	Short.
9	0.259	0.0860	0.0015	1.70	Good material.
10	...	0.0964	0.0162	16.00	Good material.
11	0.273	0.0469	0.0054	11.00	Very short.
12	0.308	0.1242	0.0243	20.00	Slightly cold-short.
13	0.343	0.5649	0.0248	4.0	Cold-short.
14	0.122	0.6212	0.0190	3.0	Cold-short.
15	0.375	0.0847	0.0171	20.0	Increasing in cold-shortness.
16	0.217	0.0677	0.0184	27.0	
17	0.168	0.0704	0.0177	25.0	
18	0.137	0.0648	0.0218	32.0	
19	0.220	0.0829	0.0218	26.0	
A	0.110	0.442	0.355	80.33	Welds easily. Very great cold-shortness.
B	0.123	0.456	0.289	63.35	Welds easily. Great cold-shortness.

The actual tests made in a testing-machine of A and B samples were as follows :—

	A	B
Tensile strength, tons per square inch . . .	27.00	22.40
Elongation on 50 millimetres, per cent. . . .	8.40	12.00
Induction in area, per cent.	29.32	25.60

[illegible]

in those with less carbon. If free phosphide is liberated, as it has been proved it is with 0·06 per cent. phosphorus and about 1 per cent. carbon, as it forms meshes round the grains, it must materially reduce the strength of the mass. If the phosphide is concentrated in a part of the iron when the carbon is lower, say between 0·5 per cent. and 0·8 per cent., that part of the structure is likely to be more liable to give way easily under sudden stress than if it was not so highly charged with phosphorus.

It must not be at this stage concluded that because generally the higher the carbon the less PH_3 is given off, and *vice versa*, that it always is the case. Possibly variations in the rate at which the liquid steels are cooled, and in the manner it is heated previous to forging, and also whether or not it is annealed, may have influence in determining in what condition of concentration the phosphide remains in the finished steel.

This section of the subject is worthy of most serious research, and it is to be hoped that the chemists in the many steelworks throughout the world will endeavour to clear away the darkness which surrounds this very complicated branch of the subject.

The hypotheses advanced at the present stage of the research can only be tentatively held, and it is not desired that they should be accepted as revealed facts.

Does Quenching Steel after Heating to High Temperatures affect the Phosphorus Condition?

(¹³) E. D. Campbell and S. C. Babcock have made certain investigations to determine whether or not the phosphorus condition is different in the same carbon steel when it is annealed and hardened. The method employed consisted in dissolving the steels in slightly acid solution of mercuric chloride, and determining the amount of phosphorus which remained in solution. The results obtained were as follows:—

The analyses of the three steels experimented upon are as follows:—

	1.	2.	3.
	Per Cent.	Per Cent.	Per Cent.
Carbon	0·100	0·37	1·22
Phosphorus	0·119	0·16	0·098
Manganese	0·484	0·82	0·780
Sulphur . . . . .	...	...	0·068
Silicon . . . . .	...	...	0·058



I intend, as soon as time will permit, to work with the method described by those gentlemen, and shall communicate the results at a later date. The conclusion they apparently have arrived at is, that varying carbon condition in a steel is coincident with varying phosphorus condition.

On the Effect of Carbon introduced into Phosphoretic Iron by the Cementation Process.

(4) Behrens and Van Linge, in studying the constitution of Dannemora cemented bar containing only 0.02 per cent. of phosphorus, found that the phosphide separated with the carbide, and according to (11) Baron Jüptner, they found that the phosphide was inside the carbide. On consulting the original paper, it would appear that on dissolving the cement bar, the authors found some phosphorus associated with the insoluble carbide, and calculated that if the whole of that element existed as Fe_3P there should have been about 0.2 per cent. insoluble.

It appeared to me that bars with so little phosphorus as 0.02 per cent. were not the best upon which to determine the reactions which take place in the cementation furnace. With the most valuable assistance of Mr. T. W. Sorby of Sheffield, without whose aid no practical results could have been obtained, I have had many pieces of phosphoretic bars, &c., carburised by cementation, and these were carefully examined.

The first sample, for which I am indebted to Mr. A. Cooper and Mr. C. H. Ridsdale, consisted of a piece of iron taken from metal during the afterblow in a basic converter, when about 0.6 per cent. phosphorus remained.

A second sample consisted of a piece of puddled bar containing about 0.5 per cent. phosphorus.

The following are the analyses after carburisation:—

<i>Basic Iron (Cemented).</i>						Per Cent.
Carbon	.	.	.	.	.	1.16
Phosphorus .	.	.	.	.	.	0.63
Phosphorus as free phosphide	.	.	.	.	.	0.02
Phosphorus in solid solution	0.61

The microscope proved that, except at the external parts, no

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which had evidently liquated from the specimen. It was detached for analysis. On fracturing the metal, a most instructive structure was revealed. (Photo No. 19.)

The metal before treatment was coarsely crystalline, with cleavage faces 3 c.m. across. After carburisation, excepting in a small kernel where the metal had escaped carburisation and where the original structure remained intact, the metal was entirely altered.

The external parts of the structure were coarsely granular, but between these and the kernel the crystalline masses were arranged in columns clearly illustrated in the photograph.

Portions were taken from fixed positions, and these were separately analysed with the following results:—

Description.	Phosphorus.				
	Carbon.	Total.	As Free Fe ₃ P.	In Solid Solution.	Lost.
	Per Cent.	Per Cent.	Per Cent.	Per Cent.	Per Cent.
Kernel centre	traces	1.46	0.44	1.02	None
Do. average	0.28	1.44	0.44	1.00	None
1	0.89	1.52	0.46	0.96	0.42
2	0.98	1.36	0.67	0.69	0.64
3	1.20	1.05	0.38	0.67	0.79
4 external layer	1.31	0.40	0.29	0.62	1.03

The drop of metal from the bottom of the piece contained

Phosphorus 4.86 per cent.

The evidence is conclusive that, as the carbon passed into the metal its dominating influence threw out the phosphide, equivalent to all excepting about 0.65 per cent., and in doing so produced sufficient gamma iron to effect a complete rearrangement of the structure. The liquid phospho-carbide eutectic thrown off to the boundaries of the grains, being continuous and extending to the exterior, simply liquated away.

As the carbon passed into the hot iron containing the solid solution of phosphide, an allotropic change under the influence of the carbide must have been gradually effected, and coincident with that change a reorganisation of the crystalline structure. The crystalline development must also have been gradual, growing steadily from the exterior to the centre coincidentally with the penetration of the carbon. White iron, zinc, and other metals

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centre. The columnar structure terminated at a distance of $1\frac{1}{2}$ centimetres from the centre, and was replaced by ordinary polygonal grains, the joints of which contained very little phosphide, but sufficient carbide to completely envelop them. Imprisoned in the centre of these grains were globular masses of eutectic, and at wide distances apart irregular-shaped masses of the same substance were segregated at the junction of three grains.

The consideration of these observations leads to the following conclusions:—

That as the carbon diffused into the mass in a forward direction, the phosphide eutectic fell out of solution in the rear, and at first the liquid eutectic so formed would be thrown entirely out of the metal and escape. As the carburisation progressed, the metal in the rear would change its allotropic state from beta to gamma iron, and would recrystallise into the well-known polygonal grains. In front of these a layer of fluid eutectic would continually be forming, but it would, as rapidly as it was formed, flow backwards along the crystalline junctions to the outside of the metal, leaving a residuum behind. The grains at first formed would in all probability be smaller than if they were left in the metal when cold, but under the long-continued action of heat would rearrange their crystalline orientation and fall together so as to form a smaller number of larger grains or columns; but in doing so the intervening eutectic could not be completely expelled, and would remain imprisoned more or less completely, and not having any free passage to escape, would at once begin to coalesce, forming at first oblong drops, which in course of time would contract to the forms more or less globular, actually present in the cold specimen.

If the specimen carburised had been perfectly globular and the carburisation regular at all times during the process, there would have been a spherical fluid area between the centre and the outside, dividing a globe of solid metal in the middle from a solid shell at the exterior, more or less cut up by fluid cells through which the liquid eutectic would continually flow, and which would eventually leave the mass of metal and fall into the charcoal surrounding it. Although the specimen was not globular, the fluid envelopment must have been developed and continual liquidation of the eutectic been effected.

1. 2. 3. 4. 5. 6. 7. 8. 9. 10. 11. 12. 13. 14. 15. 16. 17. 18. 19. 20. 21. 22. 23. 24. 25. 26. 27. 28. 29. 30. 31. 32. 33. 34. 35. 36. 37. 38. 39. 40. 41. 42. 43. 44. 45. 46. 47. 48. 49. 50. 51. 52. 53. 54. 55. 56. 57. 58. 59. 60. 61. 62. 63. 64. 65. 66. 67. 68. 69. 70. 71. 72. 73. 74. 75. 76. 77. 78. 79. 80. 81. 82. 83. 84. 85. 86. 87. 88. 89. 90. 91. 92. 93. 94. 95. 96. 97. 98. 99. 100. 101. 102. 103. 104. 105. 106. 107. 108. 109. 110. 111. 112. 113. 114. 115. 116. 117. 118. 119. 120. 121. 122. 123. 124. 125. 126. 127. 128. 129. 130. 131. 132. 133. 134. 135. 136. 137. 138. 139. 140. 141. 142. 143. 144. 145. 146. 147. 148. 149. 150. 151. 152. 153. 154. 155. 156. 157. 158. 159. 160. 161. 162. 163. 164. 165. 166. 167. 168. 169. 170. 171. 172. 173. 174. 175. 176. 177. 178. 179. 180. 181. 182. 183. 184. 185. 186. 187. 188. 189. 190. 191. 192. 193. 194. 195. 196. 197. 198. 199. 200. 201. 202. 203. 204. 205. 206. 207. 208. 209. 210. 211. 212. 213. 214. 215. 216. 217. 218. 219. 220. 221. 222. 223. 224. 225. 226. 227. 228. 229. 230. 231. 232. 233. 234. 235. 236. 237. 238. 239. 240. 241. 242. 243. 244. 245. 246. 247. 248. 249. 250. 251. 252. 253. 254. 255. 256. 257. 258. 259. 260. 261. 262. 263. 264. 265. 266. 267. 268. 269. 270. 271. 272. 273. 274. 275. 276. 277. 278. 279. 280. 281. 282. 283. 284. 285. 286. 287. 288. 289. 290. 291. 292. 293. 294. 295. 296. 297. 298. 299. 300. 301. 302. 303. 304. 305. 306. 307. 308. 309. 310. 311. 312. 313. 314. 315. 316. 317. 318. 319. 320. 321. 322. 323. 324. 325. 326. 327. 328. 329. 330. 331. 332. 333. 334. 335. 336. 337. 338. 339. 340. 341. 342. 343. 344. 345. 346. 347. 348. 349. 350. 351. 352. 353. 354. 355. 356. 357. 358. 359. 360. 361. 362. 363. 364. 365. 366. 367. 368. 369. 370. 371. 372. 373. 374. 375. 376. 377. 378. 379. 380. 381. 382. 383. 384. 385. 386. 387. 388. 389. 390. 391. 392. 393. 394. 395. 396. 397. 398. 399. 400. 401. 402. 403. 404. 405. 406. 407. 408. 409. 410. 411. 412. 413. 414. 415. 416. 417. 418. 419. 420. 421. 422. 423. 424. 425. 426. 427. 428. 429. 430. 431. 432. 433. 434. 435. 436. 437. 438. 439. 440. 441. 442. 443. 444. 445. 446. 447. 448. 449. 450. 451. 452. 453. 454. 455. 456. 457. 458. 459. 460. 461. 462. 463. 464. 465. 466. 467. 468. 469. 470. 471. 472. 473. 474. 475. 476. 477. 478. 479. 480. 481. 482. 483. 484. 485. 486. 487. 488. 489. 490. 491. 492. 493. 494. 495. 496. 497. 498. 499. 500. 501. 502. 503. 504. 505. 506. 507. 508. 509. 510. 511. 512. 513. 514. 515. 516. 517. 518. 519. 520. 521. 522. 523. 524. 525. 526. 527. 528. 529. 530. 531. 532. 533. 534. 535. 536. 537. 538. 539. 540. 541. 542. 543. 544. 545. 546. 547. 548. 549. 550. 551. 552. 553. 554. 555. 556. 557. 558. 559. 560. 561. 562. 563. 564. 565. 566. 567. 568. 569. 570. 571. 572. 573. 574. 575. 576. 577. 578. 579. 580. 581. 582. 583. 584. 585. 586. 587. 588. 589. 590. 591. 592. 593. 594. 595. 596. 597. 598. 599. 600. 601. 602. 603. 604. 605. 606. 607. 608. 609. 610. 611. 612. 613. 614. 615. 616. 617. 618. 619. 620. 621. 622. 623. 624. 625. 626. 627. 628. 629. 630. 631. 632. 633. 634. 635. 636. 637. 638. 639. 640. 641. 642. 643. 644. 645. 646. 647. 648. 649. 650. 651. 652. 653. 654. 655. 656. 657. 658. 659. 660. 661. 662. 663. 664. 665. 666. 667. 668. 669. 670. 671. 672. 673. 674. 675. 676. 677. 678. 679. 680. 681. 682. 683. 684. 685. 686. 687. 688. 689. 690. 691. 692. 693. 694. 695. 696. 697. 698. 699. 700. 701. 702. 703. 704. 705. 706. 707. 708. 709. 710. 711. 712. 713. 714. 715. 716. 717. 718. 719. 720. 721. 722. 723. 724. 725. 726. 727. 728. 729. 730. 731. 732. 733. 734. 735. 736. 737. 738. 739. 740. 741. 742. 743. 744. 745. 746. 747. 748. 749. 750. 751. 752. 753. 754. 755. 756. 757. 758. 759. 760. 761. 762. 763. 764. 765. 766. 767. 768. 769. 770. 771. 772. 773. 774. 775. 776. 777. 778. 779. 780. 781. 782. 783. 784. 785. 786. 787. 788. 789. 790. 791. 792. 793. 794. 795. 796. 797. 798. 799. 800. 801. 802. 803. 804. 805. 806. 807. 808. 809. 810. 811. 812. 813. 814. 815. 816. 817. 818. 819. 820. 821. 822. 823. 824. 825. 826. 827. 828. 829. 830. 831. 832. 833. 834. 835. 836. 837. 838. 839. 840. 84

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| Year | 18-29 | 30-49 | 50-69 |
|------|-------|-------|-------|
| 1990 | 75 | 65 | 55 |
| 1991 | 78 | 68 | 58 |
| 1992 | 80 | 70 | 60 |
| 1993 | 82 | 72 | 62 |
| 1994 | 85 | 75 | 65 |
| 1995 | 88 | 78 | 68 |
| 1996 | 90 | 80 | 70 |
| 1997 | 92 | 82 | 72 |
| 1998 | 95 | 85 | 75 |
| 1999 | 98 | 88 | 78 |
| 2000 | 90 | 80 | 70 |

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| Age Group | 2004 | 2006 | 2008 |
|-----------|------|------|------|
| 18-29 | ~85% | ~88% | ~92% |
| 30-49 | ~78% | ~82% | ~85% |
| 50-69 | ~72% | ~75% | ~78% |
| 70+ | ~65% | ~68% | ~70% |

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The following table will make this clear:—

| Pure Iron. | Phosphide. | Phosphorus. | Carbon, Calculated
as Capable of
being Absorbed. |
|------------|------------|-------------|--|
| Per Cent. | Per Cent. | Per Cent. | Per Cent. |
| 100 | None | None | 4.60 |
| 75 | 25 | 3.89 | 3.45 |
| 50 | 50 | 7.78 | 2.30 |
| 25 | 75 | 11.67 | 1.15 |
| None | 100 | 15.58 | None |

In order to ascertain if the result of actual experiment would coincide with the calculated results, mixtures of phosphide and pure iron were made so as to approximate to the above proportions of phosphorus and iron, and these were melted side by side in a charcoal brasqued crucible containing five separate compartments. The heat was regulated so as not to exceed the temperature of the blast-furnace, and was certainly not high enough to melt pure iron.

The analyses of the products were as follows, viz.:—

| Analysis of Mixture. | | Carbon in
Melted Metals. | Fracture. |
|----------------------|-------------|-----------------------------|-----------|
| Iron. | Phosphorus. | | |
| Per Cent. | Per Cent. | Per Cent. | |
| 100 | None | 4.15 | White |
| 96 | 4.10 | 3.25 | " |
| 93 | 7.90 | 2.00 | " |
| 87 | 13.00 | 0.70 | " |
| 83 | 16.00 | Nil. | " |

The results, although deviating from what was calculated, nevertheless are sufficiently close to show that the basis on which the calculations were made is fairly correct. It is well known that even from the blast-furnace the No. 1 pig irons will vary very considerably in carbon, from causes not at present fully understood. The temperature, however, *ceteris paribus*, undoubtedly has the greatest influence in determining the differences.

A second series of comparative trials were made with phosphoretic metals of known phosphorus content by carburising in

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has shown that 1·5 per cent. of phosphorus, at any rate, has no influence in preventing the separation of graphite.

A careful observer can, however, note a difference in the greyness of equally open highly phosphoretic pig iron and one practically free from phosphorus; but this is not caused by the presence of combined carbon, but is due to the fact that the free phosphide present gives a white fracture, and that the two irons contain different quantities of graphite. The combined carbon is about equal in each.

In order to ascertain the effect of large quantities of phosphorus in presence of silicon, mixtures of silico-phosphide of iron and iron in various proportions were melted in charcoal-lined partitioned crucibles. The temperature was very intense, certainly higher than that of the blast-furnace. The results were as follows :—

| | 1. | 2. | 3. | 4. | 5. |
|-------------------|-----------|-----------|-----------|-----------|-----------|
| | Per Cent. | Per Cent. | Per Cent. | Per Cent. | Per Cent. |
| Combined carbon . | 1·10 | 0·56 | 0·11 | Nil. | Nil. |
| Graphite . . . | 2·62 | 1·73 | 1·88 | 1·69 | 0·83 |
| Silicon . . . | 0·92 | 1·96 | 1·96 | 2·84 | 3·36 |
| Manganese . . . | traces | traces | traces | traces | traces |
| Phosphorus . . . | 0·21 | 4·95 | 6·85 | 8·35 | 12·86 |

It was observed that the size of the graphite plates mechanically suspended in the metals were largest in the most phosphoretic metal, and less so in those with lower percentages.

No. 1 metal had the greyest fracture; the others were less grey, the greyness decreasing with the increase of phosphorus.

The analyses prove that this decrease was not due to the presence of combined carbon, for the least proportion of that substance is found in the most phosphoretic sample; it therefore must be due to the decreasing proportion of graphite.

It is unfortunate that the silicon was not equal in each case for the sake of strict comparison; but for all that, the results are instructive, considering that the variable element silicon was not in greater proportion in the more phosphoretic metals Nos. 4 and 5 than is commonly present in grey furnace irons; and that even although not excessive, combined carbon was absent, and all the carbon capable of being absorbed was in the state of graphite.

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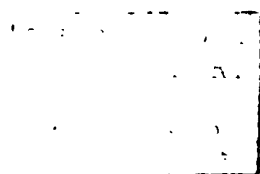
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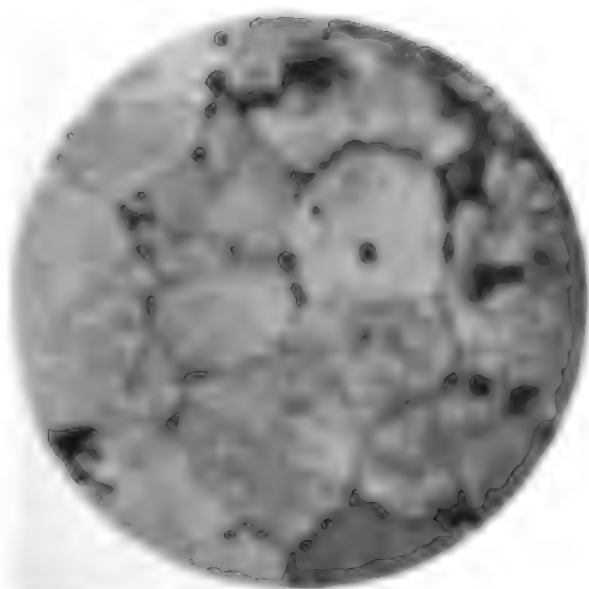
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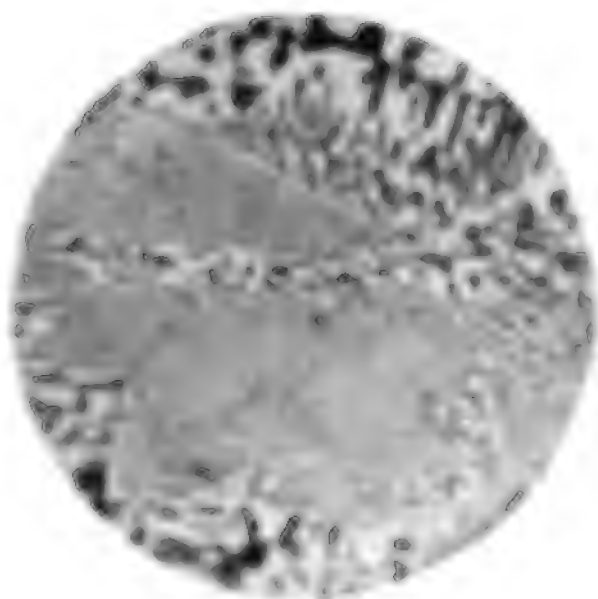
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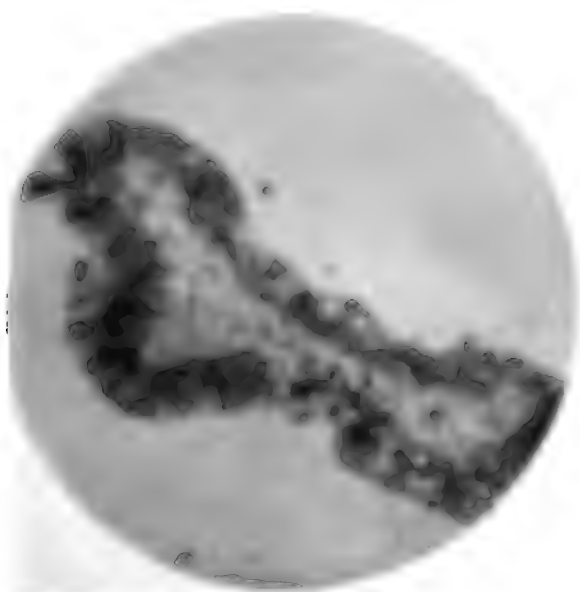
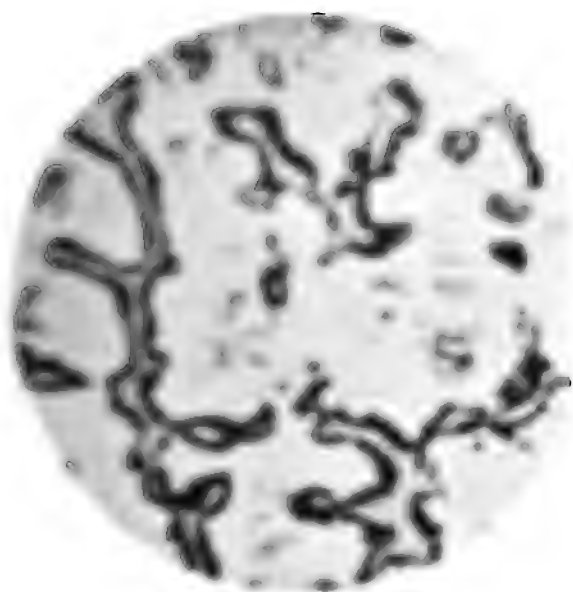


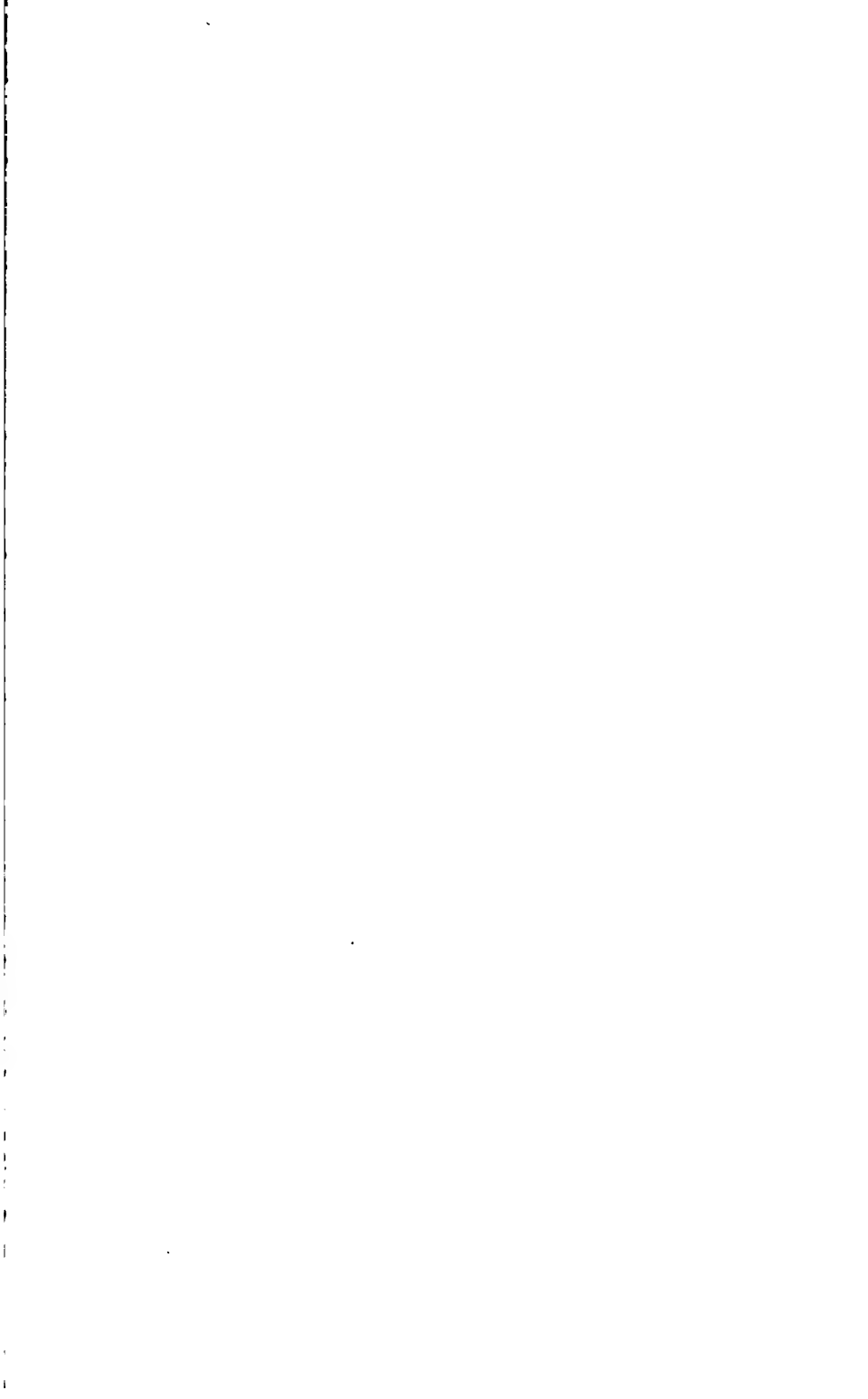
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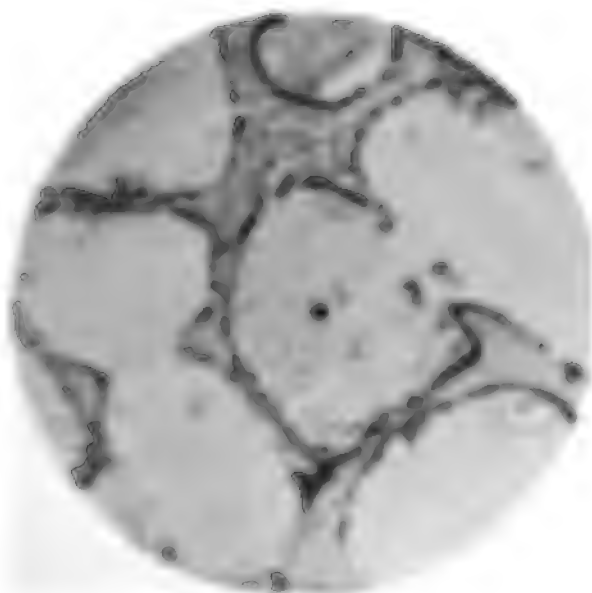


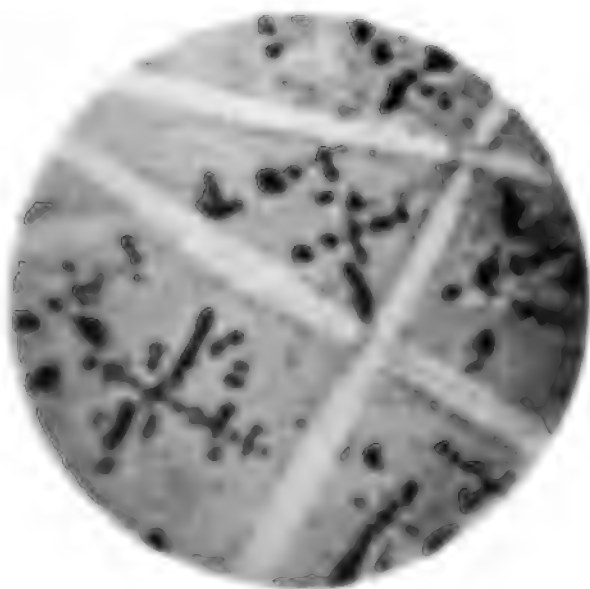












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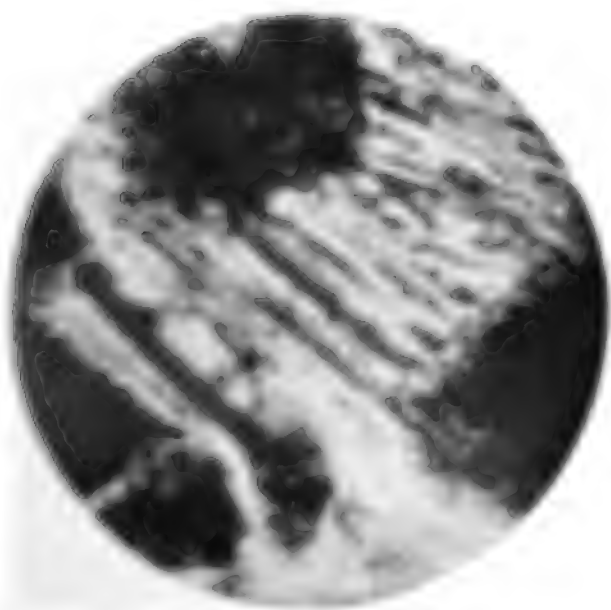


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iron by the absorption of carbon in the cementation furnace, a large part of it liquates out of the mass and falls in the liquid state into the surrounding charcoal.

7th. That when saturated solid solutions of phosphide in iron are heated or cooled, they show no thermal critical point at Ar_3 , and the structure is not broken up even when the temperature exceeds $1000^{\circ}C.$; therefore there can be no allotropic change from the beta to the gamma modification by heating to $1000^{\circ}C.$ When, however, carbon passes into the mass, a large proportion of the phosphide is expelled, and the carbon absorbed converts, at the temperature of the cementation furnace, a dominating proportion of the beta iron into gamma iron, and coincidentally the structure is entirely reorganised and recrystallisation is effected. The recrystallisation can only proceed coincidentally with the penetration of the carbon from the exterior towards the centre.

Under favourable conditions the slowly developing crystalline grains develop longitudinally into columns, which radiate to the middle of the bar.

A similar condition of crystalline development follows the change of allotropic state, but in the reverse direction, when carburetted steel is decarburised in ore or limestone at about 750° . At that temperature in presence of diffused carbide the carbon is in the gamma state, but as the carbon is removed beta iron is formed and crystallisation of the iron proceeds from the exterior to the centre of the mass, leaving a most perfect columnar structure.

8th. The proportion of phosphine, PH_3 , gas given off on dissolving phosphoretic irons free from carbon is approximately inversely in proportion to the amount of phosphorus.

When 1.7 per cent. is present, only about 4 per cent. of it escapes as gas, whereas when there is only from 0.03 to 0.10 per cent., nearly 70 per cent. of it passes off as PH_3 .

9th. When carbon is introduced into irons containing from 0.03 to 0.10 per cent. phosphorus, the proportion of phosphine liberated on solution of the metal steadily decreases with each increment of carbon, until, when the latter reaches about 1.2 per cent., only 15 per cent. of the whole escapes as PH_3 . This behaviour leads to the conclusion that there are two solutions in

1. The first step in the process is to identify the problem or issue that needs to be addressed. This involves gathering information and understanding the context of the problem.

2. Once the problem is identified, the next step is to define the objectives and goals of the project. This helps to clarify what needs to be achieved and provides a clear direction for the team.

3. The third step is to develop a plan or strategy to address the problem. This involves breaking down the problem into smaller, manageable tasks and determining the resources needed to complete each task.

4. The fourth step is to implement the plan. This involves putting the strategy into action and monitoring progress regularly to ensure that the project is on track.

5. The final step is to evaluate the results of the project. This involves assessing the outcomes against the objectives and goals and identifying any areas for improvement or further action.

[illegible]

Figure 1. The effect of the concentration of the *Agrobacterium* suspension on the transformation efficiency of *Agrobacterium* strains. The *Agrobacterium* strains were grown in YEA medium for 24 h at 28 °C. The cell concentration of the strains was adjusted to 10⁸ cells/ml. The cell suspension was mixed with the plant tissue and incubated for 24 h at 28 °C. The plant tissue was then cultured on the selective medium. The transformation efficiency was determined as the number of transformants per 100 mg of plant tissue. The data are the mean ± SD of three independent experiments.

the 1990s, the number of people in the world who are under 15 years of age is expected to increase from 1.1 billion to 1.5 billion. The number of people aged 65 and over is expected to increase from 200 million to 400 million. The number of people aged 15 and over is expected to increase from 3.5 billion to 4.5 billion. The number of people aged 15 and over is expected to increase from 3.5 billion to 4.5 billion. The number of people aged 15 and over is expected to increase from 3.5 billion to 4.5 billion.

[illegible]

contained considerably more phosphorus than the average of the pig iron from which it liquated. Since that time many observers have confirmed this result.

In 1870 I subjected to hydraulic pressure in a properly prepared mould Cleveland pig iron after practically the whole of it had solidified. The git or runner was left open when the pressure was applied, with the result that a small quantity of metal was squeezed out. The original metal and fusible portion had the following analysis, viz. :—

| | Original Metal.
No. 4 Brand. | Portion
Squeezed Out. |
|----------------------|---------------------------------|--------------------------|
| | Per Cent. | Per Cent. |
| Carbon | 3.00 | 1.75 |
| Manganese | 0.35 | 0.29 |
| Silicon | 1.63 | 0.79 |
| Sulphur | 0.12 | 0.06 |
| Phosphorus | 1.53 | 6.84 |

(¹⁵) Mr. Osmond has described certain experiments of his in which he proved the existence of a critical point in the solidification of phosphoretic pig iron at about 900° C. The analysis and critical points were as follows :—

Phosphoretic Metal.

| | |
|---------------------------|-----------|
| | Per Cent. |
| Graphite carbon | 1.50 |
| Combined carbon | 1.20 |
| Manganese | 0.74 |
| Silicon | 1.89 |
| Sulphur | 0.03 |
| Phosphorus | 1.98 |

Critical Points.

| | III. | II. | I. | Ar 1, 2, 3. |
|-------------------|------|------|-----|-------------|
| Cooling | 1065 | 1025 | 895 | 698 |
| Heating | 1050 | 1040 | 910 | 800 |

Comparative analysis and critical points of hæmatite pig iron

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Previous to heating, the metal contained—

| | Per Cent. |
|----------------------|-----------|
| Carbon | 3.50 |
| Silicon | 2.60 |
| Phosphorus | 1.90 |

The analysis of the shot, it will be observed, closely resembles the analysis of the metal which in my own experiments I squeezed out of Cleveland pig iron by hydraulic pressure.

The phenomena observed by Mr. Lencauchez is peculiar to metals containing small quantities of a fusible eutectic, or a constituent which is more fusible than the greater mass, for I have found that it is only necessary to heat such alloys or compounds a little above the melting-point of the eutectic for small globular exudations to pass out of the metal, forming little shot-like bodies all over the surface. It is not difficult to understand how this occurs, for as soon as the temperature is raised slightly above that of the liquefied eutectic it expands, and a portion of it comes out of the metal in which it was imprisoned. There is also always a tendency in heterogeneous mixtures of metals for that part which is in greater mass to throw off the others in contact with it; hence small quantities of the eutectics, where it is physically possible, are thrown into large segregated areas or entirely outside the mass.

I have most carefully repeated Mr. Osmond's experiments, and find that in Cleveland iron, when it is slowly cooled from the molten state, there is a critical point at about 900° C., thus confirming his observation. The pure eutectic of phosphorus and iron solidifies at about 980° C., so it is clear the eutectic solidifying at 900° C. must have a different composition.

On melting together some of the phosphide of iron eutectic with carbide of iron, the eutectic formed solidified at 910° C. A similar result followed on cooling a mixture of silicious pig iron with the pure eutectic.

Leopold Schneider succeeded in isolating the free phosphide of iron from phosphoretic pig irons by dissolving them in cupric chloride, and found it to correspond to the composition expressed by the chemical formula Fe_3P .

In order to isolate the eutectic from grey Cleveland iron containing 1.56 per cent. phosphorus, some lumps of it were dissolved in dilute acid. The residue, containing graphite and decomposition

plastic state; but this, as heat passes away, in time begins to solidify, commencing at the solid borders of the graphite.

This metal consists of all the iron, manganese, silicon, and phosphorus; it does not all solidify at the same time.

The crystalline combination of the greater part of the iron and manganese and all the silicon forms one part; the phosphorus and some of the iron and manganese the other part.

As the first part crystallises in advance, the remainder, consisting of the fusible eutectic, is driven before the metal, advancing in its growth on all sides of it; and finally, when they nearly approach each other, the eutectic (incapable of being forced further in any direction) is imprisoned in irregular-shaped cavities, where it remains fluid till the temperature falls to its freezing-point, when it solidifies, breaking up into its two constituents.

It follows, therefore, that the irregular-shaped solid masses of the eutectic must be found between and at a distance from the graphite plates, and this is actually where the greater number of them are located.

The photographs Nos. 14 and 15 illustrate the foregoing remarks. The first represents the structure of Cargo Fleet No. 3 iron, the second East Coast No. 1 hæmatite. They had the following composition :—

| | Phosphoretic. | Non-Phosphoretic. |
|------------------------------------|---------------|-------------------|
| | Per Cent. | Per Cent. |
| Combined carbon | 0·12 | 0·25 |
| Graphite | 3·59 | 3·86 |
| Manganese | 0·69 | 0·76 |
| Silicon | 2·76 | 2·83 |
| Sulphur | 0·05 | 0·04 |
| Phosphorus * | 1·49 | 0·04 |
| Phosphorus in solid solution . . . | 0·29 | 0·03 |

* Equal to phosphide of iron, 9·50 per cent., 0·25 per cent.

The irregular white areas in the centre of the photographs are the phosphide eutectic.

When hæmatite metal is strongly etched, so as to darken the ground-mass, and is examined with vertical light, the specks of brilliant phosphide stand out in bold relief, and appear like the

The lump of metal was about 5 inches square and 12 inches long. Whether or not it was a natural product is doubtful, but that it had cooled exceedingly slowly in passing from the liquid state was evident, for the carbon which, under less slow cooling, would have existed as pearlite, was massive cementite enveloping the graphite.

White phosphoretic irons are not quite so easy to judge as to the proportion of phosphorus present.

The presence of large masses of carbide of iron makes it impossible to tell which part is phosphide and which carbide if the simple etching method is employed; it is necessary, therefore, to use the "heat-tinting" process.

By heating till the pearlite is blue, as a rule, the cementite will be found red and the phosphide yellow. It is then quite easy to see the proportion of each, and where the eutectic joins the carbide. It has been found better to first etch with iodine to darken the pearlite, and after wiping the specimen with a clean linen rag, to heat till the required tint is obtained. This method leaves the pearlite dark. If the structure is to be photographed, it is advisable to heat until the carbide has assumed a faint yellow tinge, when the phosphide will remain quite white.

By using isochromatic plates, the prints show the phosphides white, the carbide in half-tone, and the pearlite dark.

The photographs Nos. 16 and 17 represent areas of white Clarence pig etched with iodine, and also heat-tinted in the manner described. It will be noticed how the heat-tinting in No. 17 shows up the phosphide, which is represented by the white areas.

SUMMARY OF PART III.

1st. There are fusible eutectics in all pig irons containing phosphorus, and which have solidifying points of about 900° C.

2nd. The free phosphide of iron can be left insoluble from such irons by dissolving them in cupric chloride (Schneider's method), or by nitric acid of specific gravity 1.20 in the cold. By attracting the magnetic portions of phosphide from the residue with a magnet, and further purifying what is attracted, almost pure Fe_3P is obtained.

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an exception to the rule, for it was free from carbon, and, moreover, contained not a trace of silicon and manganese. The structure resembled that of the columnar iron already referred to, with this difference, that the columns were much larger and were greatly curved. The microscope showed that they were enveloped with thin layers of phosphide of iron, and in their centres there existed small globular masses of the same substance, together with globules of sulphide of iron.

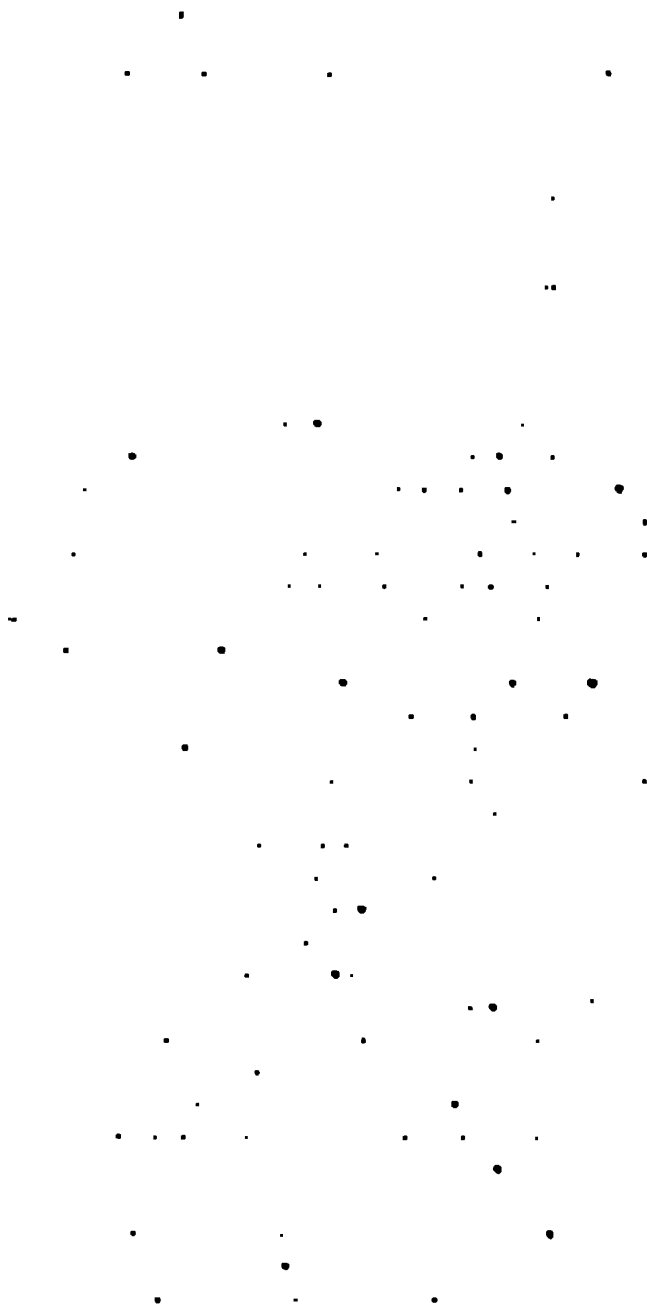
The analyses of Ferryhill pig iron and of this curious formation are as follows:—

| | Ferryhill Pig Iron. | | Sample from Furnace Hearth. |
|---------------------------|---------------------|-----------|-----------------------------|
| | Grey. | White. | |
| | Per Cent. | Per Cent. | Per Cent. |
| Iron | 91.10 | 92.90 | 91.06 |
| Graphite | 3.36 | ... | Nil. |
| Combined carbon | 0.16 | 3.20 | Nil. |
| Manganese | 0.66 | 0.25 | Nil. |
| Silicon | 2.53 | 1.10 | ... |
| Sulphur | 0.06 | 0.30 | 0.32 |
| Phosphorus | 2.01 | 2.10 | 1.98 |
| Oxygen, &c. | 0.12 | 0.15 | 0.64 |
| | 100.00 | 100.00 | 100.00 |

By crushing the sample to fine powder and removing the fine particles by sieving, the greater part of the brittle and easily crushed and free phosphides were removed. On treating the fine powder so removed with sulphuric acid, the sulphides were dissolved, together with that part of the iron which passed the sieve. The insoluble residue, consisting of a black powder and bright metallic particles, was separated into two parts by a magnet, the bright particles being attracted, the black powder remaining behind. The metallic powder had the following composition:—

| | Per Cent. |
|--------------------------|-----------|
| Iron | 84.00 |
| Phosphorus | 15.41 |
| Not determined | 0.59 |
| | 100.00 |

It is practically pure phosphide of iron, Fe_3P , proving the correctness of the microscopic observation.



the amount which actually did diffuse into the iron was short of that quantity by about 0·30 per cent.

The peculiar columnar structure of the metal was no doubt produced when the gamma iron, dominated by the carbon, changed to beta iron, when the carbon was replaced by phosphide of iron.

I am conscious, on comparing the results here recorded with those obtained by decarburising phosphorus iron in the malleable castings furnace previously given, that I am at a loss to understand why there is such a wide discrepancy in the proportion of phosphorus left in solid solution in the two cases. I am, however, certain of the facts, and it remains to find a satisfactory explanation. The conditions, which of course must have been widely different, possibly may account for the anomalous results.

Many experiments have been made in my laboratory to ascertain how phosphide of iron penetrates into steel when the former is maintained in the liquid state. One result yielded most interesting results.

Some fluid eutectic in a crucible was maintained in the liquid state at 1000° , near its solidifying point, in contact with a half-inch soft steel bar containing 0·12 per cent. carbon. The bar was placed vertically through the middle of the fluid eutectic. After keeping them in contact for about an hour, the crucible with contents was allowed to cool down. The compound mass was then sectioned for micro-examination. The bar was found partially dissolved in the eutectic, and was reduced in diameter in consequence to about $\frac{1}{4}$ -inch. On polishing and heat-tinting, and then etching by iodine, the following interesting observations were made, viz. :—

The bar was surrounded by a bright hard ring, apparently free from carbon, which was traversed by solidified “rivers” of Fe_3P , which appeared as if they had been flowing from the eutectic through the hard ring into or near to the iron core. This ring consisted of a solidified solution of phosphide of iron in iron. The temperature was never nearly high enough to melt this hard envelope. Between this hard bright ring and the bar there was a transition ring or envelope not so hard as the first, but slightly harder than the bar itself. This envelope was very thin ; it did not apparently contain any carbon, and most probably was only partially saturated with the phosphide. At certain points

but before correct generalisations can be arrived at more workers at the research are required and more of nature's revelations obtained.

In conclusion, I must acknowledge the assistance and co-operation of Sir William Roberts-Austen, Professor Bauerman, Professor Arnold, Mr. MacWilliam, Mr. F. W. Harbord, Mr. A. Richards, Mr. J. L. Potts and Mr. Duckinfield of Messrs. J. H. Andrew & Co., Ltd. of Sheffield, Mr. A. Cooper, Mr. C. H. Ridsdale, Mr. T. W. Sorby, Mr. E. H. Saniter, Mr. David Evans, Mr. Horard Livens of Messrs. Ruston, Proctor, & Co., and my own assistants.

Without the assistance of these gentlemen I could have done little work.

APPENDIX I.

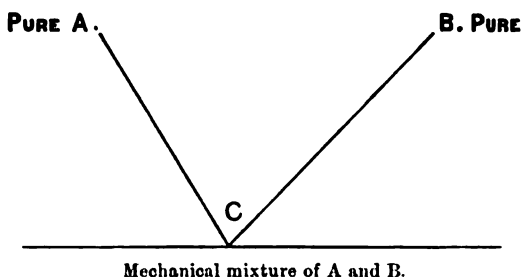
EUTECTICS.

As the words "eutectic" and "eutectic alloy" are now very generally used, it is important it should be clearly understood what is meant by the terms.

It was Guthrie who first applied it to the study of alloys.

Sir William Roberts-Austen has kindly given me his views on eutectics as follows:—

As regards the definition of a eutectic, reference to Guthrie's original paper, *Phil. Mag.*, June 1884, shows that he intended the word "eutectic" to refer to a solidified "mother liquor," that is to a mixture which has a lower freezing-point than any other of the series. The simplest case is a mixture of the two dissolved bodies A and B, the proportion of each that is present depending on their relative solubilities in each other.





together in simple multiples of their atomic weights, but in most such cases, one of the metals will separate out first and so destroy the ratio." . . . "When we are dealing with metals which, like antimony or arsenic, are themselves halogenous, or with such strongly chemico-positive metals as sodium on the other, we may and do get alloys of atomic composition or metallo-metallic salts. But the temperature of fusion of these are never, so far as I am aware, lower than that of either (both) of the constituents: they are not eutectic."

This last sentence makes it clear that one property of a eutectic, according to Guthrie, is that its melting-point must be lower than that of the mean of the separate constituents. All of the instances quoted in his paper illustrate this second principle.

Recognising that certain metals may combine to form metallo-metallic salts, Guthrie, by inductive reasoning, concluded that in an alloy such salts might be formed, and that they would take the part of a free metal and form eutectic alloys with one or other of the constituents. He says, "The very bodies resulting from the chemical union of the two metals will possibly and probably furnish starting-points of new series of eutectic alloys, consisting of a single metal on the one hand and the chemical alloy on the other."

Professor Guthrie prepared any given eutectic by melting the metals and then allowing that metal which happened to be in excess to crystallise or fall out of solution, and when the greater part had become solid, the residual alloy which still remained fluid as a kind of "mother liquor" was poured off and allowed to set. This crude eutectic was remelted and allowed to partially solidify, and the mother liquor again poured off. The same treatment was repeatedly applied until the mother liquor invariably yielded the same constant composition. This alloy when solid, but for the contradiction in terms, might have been called a solidified mother liquor. Guthrie applied the term eutectic.

A eutectic, then, must have the following properties and components:—

- 1st. A solidifying and melting point lower than that of the mean of the constituents.

The first part of the paper discusses the importance of the
 Journal of Management Education in the field of management
 education. It highlights the journal's role in providing
 a platform for the dissemination of research findings and
 the advancement of the discipline. The second part of the
 paper focuses on the journal's commitment to diversity and
 inclusion, emphasizing the need for a more equitable and
 inclusive research agenda. The third part of the paper
 discusses the journal's efforts to promote the use of
 research in management education, highlighting the
 importance of evidence-based practice. The fourth part of
 the paper discusses the journal's commitment to
 transparency and accountability, emphasizing the need for
 open access and the sharing of research data. The fifth
 part of the paper discusses the journal's commitment to
 the development of the field of management education,
 highlighting the need for ongoing research and
 innovation. The sixth part of the paper discusses the
 journal's commitment to the advancement of the
 discipline, highlighting the need for a more
 comprehensive and integrated approach to research. The
 seventh part of the paper discusses the journal's
 commitment to the development of the field of
 management education, highlighting the need for
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 ongoing research and innovation. The tenth part of
 the paper discusses the journal's commitment to the
 advancement of the discipline, highlighting the need
 for a more comprehensive and integrated approach to
 research.

maintained on the ends of the plungers. The cylinder is then slowly heated, the temperature at any moment being measured by a thermo-couple, which is placed in a hole drilled in the cylinder. At a certain definite temperature part of the alloy will liquefy, and can be squeezed out between the plungers and the wall of the cylinder. The temperature is noted at which the alloy is sufficiently liquid to be extruded. The heat is then raised, and a further portion of the alloy can sometimes be separated. Finally, a comparatively infusible residue is left. These several portions are then analysed. In some cases it is found to be desirable to subject the extruded portions to a second treatment in the compressing cylinder."

It was the hydraulic method I used in expressing the liquid eutectic from Cleveland iron, and it is the best in cases where a small quantity of the eutectic is in presence of a large mass of metal.

A third method useful in such cases where the fusing-point of the alloy is under 500°C. , and where only small quantities are available, has been employed with great advantage in my laboratory in preparing the eutectics of the fusible metals.

The melted alloy is poured upon the surface of a sheet of flexible asbestos paper. When the mass has solidified to the consistency of a thick paste, a second sheet of asbestos is placed on the top of the metal, and a wooden ruler is rolled over the plastic mass from the front in a forward direction. The eutectic is in this way squeezed out and runs as a fluid drop in front of the ruler leaving the solid metals behind. The crude eutectic so obtained is remelted and is again subjected to the same treatment. It is possible in this way to obtain the eutectic from 10 grammes of alloy.

The last method is that which I have used most extensively in the preparation of the eutectics containing two metals. It may be called the microscopic method. It is based upon the characteristic micro appearance of nearly all the eutectics, and on the statement of Guthrie, now generally recognised, that if one of the constituent metals is present in excess it will first solidify, leaving the residual eutectic to solidify at a lower temperature. The metal which falls out of the mother liquor is clearly seen in the micro section when it is properly polished

The first of these is the fact that the system is not a simple one. It is a complex system, and the behavior of the system is not predictable. The second is that the system is not a simple one. It is a complex system, and the behavior of the system is not predictable. The third is that the system is not a simple one. It is a complex system, and the behavior of the system is not predictable.

APPENDIX II.

SOLID SOLUTION.

The term solid solution has been applied to such cases, when two or more metals, in solidifying from the molten state, one or more of the metals is retained in the others, but in such a form that the highest power of the microscope is unable to detect it or them. They crystallise in a form identical with or very closely approximating to that constituent which preponderates. In a true liquid solution of salt in water, no microscope can detect any of the constituents; it appears to be homogeneous. Solid solutions of one metal in another are similar in that respect.

Sir William Roberts-Austen has kindly given me his definition of solid solution, which is as follows:—

“A solid solution is a homogeneous mixture of two or more substances in the solid state. In metals, no one has as yet worked at non-crystalline mixtures, and solid solutions of metals when crystalline are solid ‘isomorphous mixtures,’ or ‘mixed crystals.’”

This definition is a most concise one, and certainly appears to cover every kind of solid solution.

There are, however, several kinds of solid solution:—

1st. In which one metal, from an alloy in crystallising, retains a portion of the other homogeneously diffused throughout its whole crystalline mass.

2nd. In which during crystallisation the central portion of the crystals contains less of the dissolved metal than their external boundaries.

3rd. In which the metals form a definite chemical compound, which is retained in solid solution in the excess of the metal or metals.

4th. In which the non-metallic elements form definite chemical compounds with a portion of the dissolving metal and that these remain in solid solution.

The terms “isomorphous” and “mixed,” as applied to crystals, have been and still are used synonymously and are synonymous with the term solid solution in metals. The term “mixed

table until no more gas is seen to arise from the residue at the bottom. This does not take more than two minutes. The insoluble matter is then filtered off through filter paper, the residue rinsed on to the filter with cold distilled water, and the filter with contents is washed with cold water. The whole of the phosphorus existing in solid solution is by this treatment obtained in the filtrate, together with a small proportion of that existing as free phosphide of iron, whilst from 90 per cent. to 97 per cent. of the free phosphide of iron is left insoluble upon the filter. The filtrate is evaporated down to a small bulk or to dryness if silica is present, and the phosphorus determined in the usual way. The filter containing the insoluble phosphide is burned off in a platinum crucible, dissolved in nitro-hydrochloric acid, and the phosphorus determined in the solution so obtained.

On making practical trials to ascertain what effect 1·20 nitric acid has upon pure phosphide of iron, it was found that the proportion dissolved depends upon the fineness of the particles of phosphide, and the length of time the acid acted upon it, and the temperature of the acid. But on treating even the finest powder in the manner described above, not more than 10 per cent. was dissolved. Whether the quantity of phosphide (of any given fineness) acted upon is great or small, provided there is always an excess of acid at the proper temperature, the proportion dissolved is constant. The following instances indicate this:—

0·1 and 0·4 grammes of phosphide were treated side by side under the conditions above named with 25 c.c. of 1·20 nitric acid at 20° C. In each case the result was the same, 0·095 was left insoluble in the one case and 0·385 in the other, or 95 per cent. of the whole in each case. The influence of long-continued action is very pronounced, for 1 gramme of finely powdered phosphide left in contact with 1·20 nitric acid for twelve hours lost 20 per cent. of its weight, but the residue was brightly metallic, and it was absolutely free from any decomposition products. An excessive quantity of acid, if employed, makes no difference provided the temperature and time elements remain constant.

In calculating the results of any analyses, allowance must be made for the solubility of the phosphide, and in the analyses

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By heating polished sections of raw irons till they assume certain oxidation tints, their various constituents are differently coloured. The colouring depends on the formation of oxidation films, which form at different rates on the different constituents.

Professors Martens and Behrens were the first to use this method, and Osmond and others have employed it in the development of the constitutional structure of many alloys. It does not usually give any indication of the granular and crystalline structure, and stands before all other methods as a means of detecting the separate and individual constituents. It may therefore be called the constitutional method. It has the great advantage of not removing any of the metal, so that when the oxidation colouring has been effected, the original flat surface still remains. The specimens, moreover, are much less liable to rust than when chemical reagents are employed. The relative rates at which cementite, sulphide of manganese, phosphide of iron, pure iron, and pearlite—containing 0·6 per cent. phosphorus—assume various colours when heated, were carefully determined in the following manner:—

A slowly cooled sample containing all the above-mentioned constituents, excepting pure iron, had a fine hole drilled in it, and a piece of pure iron was inserted into this; the iron was then compressed so as to expand and perfectly fill the hole. After polishing it was bedded on sand in a porcelain capsule. The capsule was dropped into the circular opening on the stage of a Becks star microscope. A small spirit-lamp placed under the stage capsule was used to slowly heat the section. The changes of colour were carefully noted, with the following results, viz. :—

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No. 3.—*Table of Heat Tints.*

At constant temperature of 280° C.

| | Pearlite.
0.6% P. 0.75% C. | Iron. | Carbide of Iron. | Phosphide of Iron. |
|----------|-------------------------------|------------|------------------|--------------------|
| 1 min. . | Brown | Yellow | Brownish yellow | White |
| 2 „ . | Purple | Red brown | Do. | Do. |
| 3 „ . | Deep purple | Brown | Do. | Do. |
| 4 „ . | Blue | Purple red | Do. | Very pale yellow |
| 6 „ . | Do. | Purple | Orange brown | Pale yellow |
| 11 „ . | Do. | Blue | Red brown | Pale salmon |
| 15 „ . | Pale blue | Do. | Burnt sienna red | Do. |
| 30 „ . | Paler blue | Paler blue | Purple brown | Heliotrope |

No. 4.—*Table of Heat Tints.*

At constant temperature of 326° C.

| | Pearlite. | Iron. | Carbide of Iron. | Phosphide of Iron. |
|----------|----------------|----------------|------------------|--------------------|
| 1 min. . | Purple red | Red | Yellow brown | Very pale yellow |
| 2 „ . | Deep blue | Purple red | Red brown | Pale yellow |
| 3 „ . | Do. | Do. | Do. | Do. |
| 4 „ . | Do. | Do. | Do. | Do. |
| 5 „ . | Do. | Deep blue | Do. | Pale salmon |
| 6 „ . | Paler blue | Lighter blue | Purple red | Salmon |
| 7 „ . | Pale sea-green | Very pale blue | Purple | Do. |
| 8 „ . | Do. | Do. | Do. | Do. |
| 9 „ . | Pale yellow | Do. | Do. | Purple |
| 10 „ . | Do. | Do. | Do. | Heliotrope |

In high carbon steels and white irons the free phosphide is always accompanied by cementite or carbide of iron, and it is easy to distinguish them by heating to 280° C. for ten to fifteen minutes. After such treatment the cementite will be red brown after each heating, whilst the phosphide will be pale yellow after ten minutes' heating, and salmon colour after fifteen minutes. On continuing the heating, the blue at first assumed by the phosphide of iron is quite different from that of any of the other constituents. It may be described as heliotrope in tint.

When no cementite is present, it is advisable to heat at 280° C. along with specimen chips of phosphide and white Swedish pig iron and pure iron, and watch the tints on these three indicators. As soon as the white iron has assumed a brown colour, the phosphide a pale yellow or salmon tint, and

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once re-heated to the proper temperature, and as soon as the tints have developed it is placed at once on a bath of mercury to cool it rapidly and avoid further change.

SPECIAL ELECTRICAL APPARATUS FOR "HEAT TINTING."

By arrangements such as have already been described, the tinting can be done under the microscope by the flame of a spirit-lamp, but the stage becomes highly heated, which is very objectionable. I have, therefore, devised a simple electric heater, which can be placed on the microscope stage, and the progress of the tinting observed. The following description, with the assistance of Plate I., will make the construction of the apparatus intelligible.

The bed is of ebonite, and on this two strips of brass are screwed, one on each side of the upper surface. To these are attached the binding screws AA.

The carrier consists of a small 1-inch porcelain capsule, on two opposite sides of which a closely fitting sheath of brass is secured. These, when it is placed in position, form the contacts with the two conducting brass strips on the bed.

The bottom of this capsule is filled with magnesia made plastic with a solution of chloride of magnesium. A platinum spiral is bedded upon this, and the terminals connected to the brass sheaths. Over the wire is painted a thin layer of silica paint, made by mixing silicate of soda and silica to the consistency of a thin paste, after which the apparatus is ready for use.

The porous magnesia under the wire is a good non-conductor, and practically no heat passes to the microscope stage.

The capsule is quite loose, and can be removed from its bed or swivelled to any angle, so that a specimen placed upon it can always be made to have its polished surface parallel with the stage.

The current can be switched off as soon as the proper tinting is obtained.

This simple apparatus will no doubt be found to be very useful where there is a supply of electricity.



15. OSMOND.—“Etudes Metallurgiques.” *Annales des Mines*, July to August 1888.
16. LENCAUCHEZ.—*Mémoires de la Société des Ingénieurs Civils*, May 1887.
17. STEAD.—“Crystalline Structure of Iron and Steel.” *Journal of the Iron and Steel Institute*, May 1898.
18. STEAD.—“Note on the Structure of Phosphoretic Pig Metals.” *Journal of the Cleveland Institute of Engineers*, February 1900.
19. HOWE.—“Metallurgy of Steel,” New York, 1891. This work contains the most complete account of the effect of phosphorus on the physical properties of steel.
20. BAUTERMAN.—“Systematic Mineralogy.” London, 1881, p. 336.
21. HOGG.—“On Segregation in Steel,” p. 238. *Journal of the Society of Chemical Industry*, March 1893.
22. SIR W. ROBERTS-AUSTEN.—“Fourth Report to the Alloys Research Committee.” *Proceedings of the Institution of Mechanical Engineers*, 1897, p. 31.

The first part of the paper is devoted to a discussion of the
 various methods which have been proposed for the determination of
 the rate of reaction between a radical and a molecule. The
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 various methods which have been proposed for the determination
 of the rate of reaction between a radical and a molecule.

respect to the diagram under the head of phosphorus and iron, he had followed with great interest Mr. Stead's graphic description, and was sorry that he stopped so soon. He had wished to hear from Mr. Stead what relation there was between the crystals of Fe_3P and Fe_2P when they occurred together. Thus, for example, the solid solution of iron passed into Fe_3P through the intervention of a eutectic. Was there anything of the same kind between the compounds Fe_3P and Fe_2P ? Some indication of this should appear in the curve of fusibility of the metals. He should like to know whether Mr. Stead obtained this curve in the usual method by taking cooling curves, as had so often been done in the case of carburised iron. He had only to add how much they were all obliged to Mr. Stead for his extremely patient explanation of the very difficult subjects he had been considering, and his own admiration for Mr. Stead's most beautiful photographs.

Mr. ALBERT LADD COLBY (South Bethlehem, Pennsylvania) wished to say a word with reference to Mr. Stead's suggestion that a committee of practical men from steelworks be formed to study the practical side of the question, and, if possible, to make practical deductions from this theoretical study of the effect of phosphorus on iron and steel. He thought the suggestion an excellent one, and hoped that when the Committee was formed, that American steelworks would be represented, for they would be very glad to aid in such an important investigation.

Mr. EDWARD RILEY (London) said that in years gone by there was a very common iron in South Wales which had pea-like exudations from the high phosphorus pig iron liquating out.

Sir THOMAS WRIGHTSON, Bart., M.P., asked, as to the welding of the phosphide, whether there was any pressure brought to bear upon the materials, and whether any tests were made to see that the junction had been absolute?

Mr. STEAD in reply said, with regard to the question of Dr. Stansfield about idiomorphic crystals of Fe_3P , he thought he had stated that they were not eutectic, but actual solid

1. The first part of the document is a title page. It contains the title "THE HISTORY OF THE UNITED STATES OF AMERICA" and the author "BY JAMES M. SMITH".

2. The second part of the document is a preface. It contains the text "PREFACE" and the author "BY JAMES M. SMITH".

3. The third part of the document is a list of contents. It contains the text "CONTENTS" and the author "BY JAMES M. SMITH".

4. The fourth part of the document is a list of names. It contains the text "LIST OF NAMES" and the author "BY JAMES M. SMITH".

5. The fifth part of the document is a list of dates. It contains the text "LIST OF DATES" and the author "BY JAMES M. SMITH".

6. The sixth part of the document is a list of places. It contains the text "LIST OF PLACES" and the author "BY JAMES M. SMITH".

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9. The ninth part of the document is a list of things. It contains the text "LIST OF THINGS" and the author "BY JAMES M. SMITH".

10. The tenth part of the document is a list of actions. It contains the text "LIST OF ACTIONS" and the author "BY JAMES M. SMITH".

The nature of the experiments was as follows, viz.:—Several pieces of sheet iron were piled one on the top of the other, but between each piece a little phosphide eutectic in powder was laid. The pile was then heated in a crucible to about 1000° for ten minutes, and was allowed to cool. On examination, the pieces were found to be perfectly welded together. The phosphide eutectic had become liquid, and had united with the surface of the iron, and the excess of the fluid portion had run out at the sides, leaving perfect junctions of solid solution of phosphide in iron. On polishing the sections, the joints were found to be relatively harder than the unaltered metal, and on heat-tinting coloured in advance of the pure iron. When the iron had assumed a yellow tint the junctions were a beautiful blue colour.

CORRESPONDENCE.

Mr. E. H. SANITER sent the following contribution:—

I have read Mr. Stead's able and exhaustive paper with great interest, and must thank him for supplying us with so many new facts and such beautiful photo-micrographs, and particularly for the new and gorgeous application of the heat-tinting process, which has been so useful in making his research complete. Any one who has seen one of his heat-tinted objects under the microscope will not soon forget it.

In his remarks on "crystalline form," Mr. Stead states that he heated a metal containing 1.15 per cent. of phosphorus, and argues that, as the cleavages were the same before as after heating, no allotropic change had taken place. This may be true, but the reasoning does not appear conclusive, as the metal would naturally revert to its former state on cooling. The photo-micrograph marked A. may throw some light on this point. This is taken from the face of a cube of iron containing 0.35 per cent. of phosphorus and no carbon, etched in calcium chloride at a bright red heat. The sides of the cube were parallel with the sides of the photograph. The peculiar structure here developed, showing markings of plates at various angles and not parallel to the sides of the cube, would seem to indicate a change of structure

I am inclined to agree with Mr. Stead that too rapid cooling and want of mass has prevented his results on page 87 arriving at a state of equilibrium.

Further, a possible error of 3 per cent. in estimating the free Fe_3P , or variation in the sample, quite alters Mr. Stead's calculation in Part II. For instance, if we take the phosphorus as free Fe_3P to have been 1.45 instead of 1.40, we get the following figures:—

| | Per Cent. | Carbon
per Cent. | Phosphorus
per Cent. |
|--|-------------|---------------------|-------------------------|
| Carbide of iron, massive . . . | 48.4 | = 3.23 | ... |
| Pearlite containing { 64 per cent. C. }
{ 62 per cent. P. } | 42.0 | = 0.27 | 0.26 |
| Phosphide of iron (free). . . . | 9.3 | ... | 1.45 |
| | <u>99.7</u> | <u>3.50</u> | <u>1.71</u> |

showing that a very small analytical error would make Mr. Stead's figures agree with mine; but I do not argue from this that either Mr. Stead's or my calculation are valuable, but that under the circumstances they are not convincing.

Let me now apply a similar calculation to No. 3 sample, containing 0.18 per cent. of carbon:—

| | Per Cent. | Carbon
per Cent. | Phosphorus
per Cent. |
|--|--------------|---------------------|-------------------------|
| Pearlite containing { 64 per cent. C. }
{ 62 per cent. P. } | 24.0 | = 0.18 | 0.16 |
| Phosphide of iron (free). . . . | 3.8 | = ... | 0.59 |
| Solution of phosphide in iron containing
1.75 per cent. of phosphorus . . . | 72.2 | ... | 1.26 |
| | <u>100.0</u> | <u>0.18</u> | <u>2.01</u> |
| | | | <u>1.77</u> |

Showing a deficiency of . . . 0.24 per cent.

Here again the calculation disagrees with the actual results. It is difficult to understand why so large a quantity of phosphide as is represented by 0.59 per cent. of phosphorus should have been thrown out of solution by 0.18 per cent. of carbon, as the rapid cooling is not likely to assist in this. It would appear that a very small amount of carbon disturbs the solid solution point of 1.75 per cent. of phosphorus.

The further fusing experiments and the cementation experiments are exceedingly interesting, and confirm the variations of the amount of free phosphide caused by varying carbon and phosphorus contents under varying conditions, and it is this

1. The first part of the document discusses the importance of maintaining accurate records of all transactions, including sales, purchases, and expenses. It emphasizes the need for regular reconciliation and the use of reliable accounting software to ensure data integrity.

2. The second part focuses on budgeting and financial forecasting. It outlines the process of setting realistic budgets, monitoring actual performance against targets, and adjusting plans as needed to stay on track.

3. The third part covers risk management and insurance. It identifies potential risks to the business, such as property damage, theft, and liability, and recommends appropriate insurance coverage to mitigate these risks.

4. The fourth part addresses tax compliance and optimization. It provides an overview of current tax laws, discusses common deductions and credits, and offers strategies for minimizing tax liability while remaining compliant.

5. The fifth part discusses the importance of cash flow management. It explains how to monitor cash flow, identify areas of improvement, and implement strategies to ensure sufficient liquidity for business operations.

6. The sixth part covers the topic of business valuation. It outlines the factors that influence a business's value, such as revenue, profit, and market position, and provides methods for estimating the company's worth.

7. The seventh part discusses the importance of legal and regulatory compliance. It highlights key areas such as employment law, consumer protection, and industry-specific regulations, and advises on how to stay up-to-date with changing requirements.

8. The eighth part covers the topic of succession planning. It discusses the importance of having a clear plan in place for the transfer of ownership and management, and provides guidance on how to develop and implement such a plan.

9. The ninth part discusses the importance of maintaining accurate financial statements. It outlines the requirements for preparing financial statements, including the balance sheet, income statement, and cash flow statement, and provides tips for ensuring their accuracy.

10. The tenth part covers the topic of business exit strategies. It discusses the various options available for exiting a business, such as selling, liquidation, or passing it on to family members, and provides guidance on how to prepare for a successful exit.

The acceptance of the above idea, or even only that there may be some change of state ready to take place in the metal, may lead to the explanation of why a metal bar or shaft, after working or running safely for years, should suddenly break under exactly normal conditions, and without any extra strain being put upon it. The constant vibration or oscillation may tend to assist such change, so that in the course of time the internal pressure, assisted perhaps by temperature fluctuations, may produce a flaw, or, given a flaw, may help to finish the fracture. In this direction the test for segregation mentioned in this paper should be one of great practical importance.

I should like to inquire if the heat-tints given for the pearlite containing 0·6 per cent. P and 0·75 per cent. C would be the same with a pearlite containing no phosphorus? If they are not, then the present material is a body different to pearlite, and its name should be altered or qualified. Under any circumstances, I think some indication of its containing phosphorus should be given. Taking pearlite as $(21 \text{ Fe} + \text{Fe}_3\text{C})$, the figure 0·75 per cent. C would produce about 85 per cent. of it, leaving 15 per cent. of a substance containing about 4 per cent. of phosphorus, or say 25 per cent. Fe_3P , which, according to the author, should also show a pearly structure. It is hardly sufficient, however, at the present time that a definite name like pearlite be given to a number of substances because they are pearly in appearance. I suggest that the present pearlite should be called phospho-pearlite, to distinguish it from what is now understood to be pearlite, or phospho-carbo-pearlite, in anticipation of the possible increase in the members of the pearly family. Is there not room for more exactness in metallurgical nomenclature? I do not mean in foundries and works, where it is hopeless, but in the scientific development of the subject. It is becoming more and more involved every year, and it cannot be made too precise and consistent in consideration of its future study. For this reason I think the appendices to the paper considerably enhance its value.

Mr. STEAD forwarded the following reply to the correspondence on his paper:—

In answer to Mr. Saniter's remark with reference to the

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1. *Chlorophyll a* and *Chlorophyll b* were determined by the method of Lichtenthaler and Whistler (1973). The *Chlorophyll a* and *Chlorophyll b* contents were expressed as mg g⁻¹ of fresh weight.

Figure 1. The effect of the concentration of the *Agrobacterium* suspension on the transformation efficiency of *Agrobacterium* strains. The number of transformed cells was determined by the number of colonies growing on the selective medium. The results are the mean of three independent experiments. Error bars represent standard deviation.

[illegible]

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Figure 1. The effect of the concentration of the *Agrobacterium* suspension on the transformation efficiency of *Agrobacterium* strains. The number of transformed cells was determined by the number of colonies obtained on the selective medium. The results are the mean of three independent experiments. Error bars represent standard deviation.

1. *Journal of the American Medical Association*, 1997; 277: 1033-1038.

[illegible]

Journal of Management Education 30(6)br/>© The Author(s)
10.1177/0095647206289111
<http://jme.sagepub.com>

[illegible][illegible]

1. *Journal of the American Medical Association*, 1997; 277: 1033-1036.

Figure 1. The effect of the concentration of the *Agrobacterium* suspension on the transformation efficiency of *Agrobacterium* strains. The number of transformed cells was determined by the number of colonies obtained after 48 h of growth on the selective medium. The results are the mean of three independent experiments. Error bars represent the standard deviation.

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^a The number of subjects who were included in each group was 10.

Journal of Management Education 30(6)p. 789-804
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1. *Journal of the American Medical Association*, 1990; 263: 1025-1028.

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lead to a modification of the conclusions. The point raised is useful, as showing the necessity of further proofs.

It is pointed out by Mr. Saniter that a unit of carbon throws out a greater proportion of phosphorus from a saturated solid solution than from one containing less phosphorus. The reason for this is not far to seek, for, as has been shown in the paper, the phosphorus is feebly held in solution in the saturated compound, and very slow cooling from a high temperature is sufficient to cause some of it to separate even without any carbon at all.

In answer to Mr. A. Wingham with regard to the question of internal pressures and strains when metals solidify, it is possible that films of the eutectic may have a destructive influence on the metal. It must not be forgotten, however, that after the formation of the eutectics, in cooling down to the normal atmospheric temperature, the molecules of all the constituents are still active and mobile, and apparently more or less migratory and inter-diffusive. When the cooling is exceedingly slow, any disruptive or strained position most probably will be, in such cases, neutralised by the molecular re-adjustment of the particles.

It is certain, as Mr. Wingham mentions, that the molecular pressure on the mass of cooling pig iron is responsible for the formation of the white portions in the centres of certain pig irons. A most notable example of this was given by myself in the discussion on Sir Thomas Wrightson's paper on "Some Physical Changes occurring in Iron and Steel at High Temperatures," read before this Institute in 1880.

I have long wished for the time and opportunity to determine exactly what takes place when minute quantities of mercury causes brittleness in tin or zinc. I am inclined to believe it forms a brittle alloy along the planes of the cleavage. It does not appear ever to have been stated that because a metal is crystalline it is therefore brittle. All metals in commercial use are crystalline. Brittleness has been shown to take place in certain pure irons in which the general orientation of the crystalline axes of the crystalline grains, with relation to the exterior surfaces, were practically all in the same direction. In such cases fracture was readily effected along the general directions of the principal cleavages, but in no other directions.

I am far from knowing all that could and will be learnt

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IRON AND STEEL AT THE UNIVERSAL EXHIBITION, PARIS, 1900.

BY PROFESSOR H. BAUERMAN, ORDNANCE COLLEGE, WOOLWICH.

THE following paper, which has been prepared mainly for the use of the members of the Institute visiting the Exhibition during the meeting, is intended to serve as a summary guide to the more prominent exhibits, and not as a complete analysis of the whole collection, for which purpose more space would be required than could reasonably be asked for. It may, however, be useful to say a few words, by way of introduction, on the general principles of arrangement adopted, using, by way of reference, the excellent plan attached to the detailed programme of the meeting.

1. *Classification*.—According to the scheme adopted by the Commission of the Universal Exhibition, the subjects of mining, metallurgy, and metal manufactures are included in Group XI., which is subdivided into the following classes:—

- Classe 63. Exploitation des Mines—Minerals and processes of mining.
- Classe 64. Grosse Métallurgie—Smelting and heavy forge and foundry work.
- Classe 65. Petite Métallurgie—Small metal-work, hardware, &c.

The bulk of the exhibits in these classes are to be found in the Palais des Mines et de la Métallurgie, which occupies the northern end of the eastern part of the twin building on the Champ de Mars. This covers about seven acres, the space being nearly equally divided between France and foreign countries; and the same arrangement is followed in the gallery, where, however, the French and foreign sections are separated by the retrospective or centennial exhibition. The mining exhibits in Class 63 are to be found mostly along the northern and eastern walls of the ground floor; those of the smaller metallurgy,

AMERICAN MEDICAL ASSOCIATION
 PUBLISHED WEEKLY
 CHICAGO, ILL., U.S.A.
 Vol. 41, No. 1, January 1951
 Single Copies 15 Cents
 Annual Subscription \$4.00
 Foreign and Post Office Subscriptions \$5.00
 Entered as Second-Class Matter, May 26, 1902
 Post Office at Chicago, Ill., Paid
 Post Office No. 302
 Second-Class Postage Paid
 Acceptance for mailing at special rate of postage provided for in Section 1103, Act of October 3, 1917, authorized on July 11, 1947.
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 Printed at the American Medical Association, 535 North Dearborn Street, Chicago 10, Ill.
 Second-Class Postage Paid
 Post Office No. 302
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 Acceptance for mailing at special rate of postage provided for in Section 1103, Act of October 3, 1917, authorized on July 11, 1947.
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of Longwy and Nancy. From this we gather that the workings of oolitic ore are mainly concentrated in two areas known as the basins of Nancy and Briey. In the former the mining area is about 72 square miles, the ore-bearing formation being about 35 feet of marls and limestones, containing three beds of mineral varying considerably in quality, the best ore being got from the upper bed in the north, and from the lower one in the south, the workable thickness varying from 8 to 14 feet, according to the nature of the different beds. The output of this district was 1,700,000 tons in 1899.

In the Briey basin, which is the more important region, with a conceded area of 120 square miles, there are no outcrop mines, the ores being all deep-seated; but they have been systematically proved by more than 150 borings, at a cost of about £120,000. The principal deposit, the so-called grey bed (*mine grise*), which resembles unweathered Cleveland or Northamptonshire stone, contains 35 to 42 per cent. iron, about 0.9 per cent. phosphorus, 7 to 15 per cent. lime, and 5 to 7 per cent. silica, the waste constituents being in such proportion as to require a certain addition of siliceous flux, which is supplied by some of the leaner ore of the associated yellow, red, and black beds. The grey bed varies between 7 and 25 feet in thickness, and the depth below the surface from 250 to 850 feet. The quantity of ore contained in the region is estimated at about 2000 million tons, about one-half of which may be got by systematic mining. The most active working centres at present are at the northern end, in the district of Longwy and Villerupt, with an output in 1899 of 2,400,000 tons. The total production of iron ore in France is about 5,000,000 tons, the Meurthe and Moselle region contributing over 80 per cent., and in the same year the blast-furnaces of that department produced 1,576,000 tons, out of the total make of pig iron of 2,576,000 tons. It is expected, however, that with increased development of the mines and facilities for transport, a total make of 2,500,000 tons in the department may be attained in the next ten years. Considerable difficulties have been experienced in opening the deep mines, owing to the large quantity of water encountered in sinking, which, in some instances, has led to the necessity of adopting the Poetsch system of freezing the water-bearing strata around the side of the shaft.

represented, the exhibits being grouped separately, but with a certain uniformity of arrangement, about the central octagon, under the title of *Collectivité de le Loire*, which includes the following works:—Saint-Chamond, Marrel Brothers, Firminy, Unieux, Brunon & Valette, Saint-Étienne, and Claudisson & Co. Prominent among them is the large collection of the *Compagnie des Forges et Acieries de la Marine et des Chemins de Fer*, proprietors of the well-known works of Saint-Chamond, Asailly, Rive de Gier, and Givors, in the neighbourhood of Saint-Étienne, and the *Forges de l'Adour* at Le Boucau, near Bayonne. This includes iron and steel work for uses in military, naval, and railway service, and is supplemented by a large show of ordnance and armour-plates in the naval and military building on the *Quai d'Orsay*. The great extent of these collections, which require a catalogue of 40 quarto pages for their description, renders it impossible to give even the most summary analysis of their contents, further than to state that Saint-Chamond contributes heavy castings and forgings for artillery, with models of the 100-ton ingot used for naval guns, one of the castings for a 6000-ton forging press lately erected, a rough hollow forging of 26 tons for the tube of a 12-inch naval gun, worked under a steam-hammer upon a mandrel, several finished gun forgings of smaller sizes, a fine collection of tested locomotive and waggon tires, and an interesting series of fractures and test-pieces of structural steel of all kinds between 25 and 48 tons tensile strength. Among these the special steel of Saint-Chamond, containing both chromium and nickel, ranges, according to hardness, between 41 and 48 tons in tensile strength, with 19 to 23 per cent. elongation, and the 26 per cent. nickel steel gives 46·5 tons with 65 per cent. elongation on a length of 4 inches. The basis of these objects is open-hearth steel, using for the bath Sardinian magnetic, Spanish, and Algerian ores, which, when necessary, is specially refined to reduce sulphur and phosphorus to a maximum of 0·01 per cent., and as malleable material, iron puddled from the same class of pigs in a rotatory furnace with separate melting bed, taking 20-cwt. charges and producing about 8½ tons of puddle blooms in twenty-four hours. For ordnance, the ingots are reduced by forging to one-fourth of their original cross section, and in weight by 50, or, in some cases, 60 per

[The page contains faint, illegible markings and noise.]

tubes and machinery castings, a finished connecting rod in nickel steel for a new transatlantic steamer, railway tires up to 10 feet 3 inches diameter, a steel shell of 420 mm., which penetrated a 550 mm. steel armour-plate, and tool steels of various kinds, including one of a specially hard character for which the name of "*acier Satan*" has been selected.

In the exhibit of the Forges and Steelworks of Saint-Étienne, a method of making heavy projectiles from conical steel ingots, shown in different stages of transformation, as well as a system of compressing steel ingots, are specially noticeable, besides some fine examples of large hollow forgings and plates for gun-shields.

Messrs. Jacob Holtzer & Co. of Unieux have a large and very varied exhibit of objects almost exclusively in crucible cast steel. The basis of the manufacture is charcoal pig iron from Ria in Corsica, which is partly converted into steel by puddling, but principally by cementation and fusion in crucibles. Gas-melting furnaces are used containing 30 to 32 crucibles, each one admitting of the production of ingots up to 6 tons. Among the most notable objects, in addition to the famous Holtzer projectiles, are castings for the framing of T. B. D. engines, cylinder cones for large marine engines, deck and shield plates for naval guns, and a remarkable series of tests of steels with varying proportions of chromium from 5 to 30 per cent., the carbon being kept constant at 0·4 per cent. The mechanical properties of these alloys are shown in the following table:—

| Chromium. | Condition. | Elastic Limit. | Breaking Stress. | Elongation. | Contraction.* |
|-----------|-----------------------|--------------------|--------------------|-------------|---------------|
| Per Cent. | | Tons per Sq. Inch. | Tons per Sq. Inch. | Per Cent. | |
| 5 | Annealed | 17·8 | 31·8 | 24·0 | 0·240 |
| | Hardened and tempered | 48·8 | 55·2 | 12·0 | 0·370 |
| 10 | Annealed | 22·9 | 42·0 | 21·5 | 0·440 |
| | Hardened and tempered | 42·4 | 54·3 | 12·0 | 0·536 |
| 15 | Annealed | 25·4 | 45·3 | 18·5 | 0·500 |
| | Hardened and tempered | 48·8 | 58·1 | 11·5 | 0·546 |
| 20 | Annealed | 21·2 | 36·1 | 21·5 | 0·465 |
| | Hardened and tempered | 27·6 | 40·3 | 19·5 | 0·515 |
| 25 | Annealed | 29·8 | 42·2 | 18·0 | 0·621 |
| | Hardened | 27·6 | 40·4 | 20·0 | 0·500 |
| 30 | Annealed | 31·8 | 41·6 | 19·0 | 0·620 |
| | Hardened | 28·8 | 39·0 | 19·0 | 0·650 |

* Ratio of fractured to original section.

send a very full series of products illustrating their operations, including coke and by-products made in Otto and Coppée ovens, cast iron from alluvial and oolitic ores, and basic steel ingots and forgings in various stages of manufacture. A more special interest attaches to the steels with high percentages of nickel produced at the Imphy Steelworks, which have been described in an important memoir by Mr. Guillaume, published a short time ago. These by special heat treatment can be made to vary in physical properties in a very remarkable manner, being made magnetic or non-magnetic at will, and their dilatation by heating can be similarly varied. The latter property has been applied to the production of wire having the same co-efficient of expansion as glass, and therefore capable of replacing platinum in the manufacture of incandescent electric lamps. Another alloy with 35 per cent. of nickel is practically non-dilatable at ordinary temperatures, the co-efficient of extension being only $1/500,000$ per degree Centigrade. This has been applied to the construction of pendulums for observatory clocks and standard bars for geodetic purposes. These products are also exhibited in the Military Pavilion, where they can be more readily examined, the light being better than in the main building.

The Société des Acieries de France, having its principal works at Isbergues, near Bethune, produces both Bessemer and open-hearth steel from Spanish, Algerian, Elban, Greek and other high-class ores, imported through Calais and Dunkirk, which are smelted with coke made from local coal, with some occasional supply from England, the pig irons melted being of the highest quality, with a maximum of 0.05 phosphorus and 1.25 to 1.90 manganese. The products are very largely rails, among which some heavy flanged forms for tramways weighing up to 105 lbs. per yard, with a groove in the head $1\frac{3}{8}$ inches deep, and very thin web and flange are noticeable as examples of difficult sections. And more remarkable is the new fish-plate joints for chair-rails adopted by the Western Railway of France. These are about 5 feet long, the principal plate, which has a foot about 8 inches broad, weighing 127 lbs. to the yard, is of an irregular form, which was specially difficult to roll with cast iron rolls, and when many of these had been broken, cast steel finishing rolls, one of which,

and silicon, with details of their tensile strength, elongation, &c. This collection, which is a very full one, is partially duplicated in the same Company's exhibit in the Naval and Military Pavilion.

One of the most effective displays in Class 64 is that made by the Forges de Douai, whose exhibit, consisting largely of pressed work, such as furnace plates, steam domes, manhole covers, and other boiler fittings, shafts and cranks for marine engines and locomotive wheels, arranged as a tall arch, formed a fitting entrance to the Metallurgical Section from the main door of the Palais.

The Escaut and Meuse Company of Anzin and Val Benoit, near Liège, exhibit many large examples of tubes, both solid drawn and welded. The former are made from solid ingots by the Mannesmann and Robertson processes, and the latter both by butt and lap welding. Among these are a rolled strip 7 inches wide, 0·12 inch thick, and 213 feet long; another of 19·7 inches wide, 0·2 inch thick, and 151 feet long; lap welded tubes 13·8 inches diameter and 20 feet long; a brine circulating tube for the Poetsch freezing process; perforated and cupped ingots from 5 to 90 feet, made by one passage of the hydraulic press, and a weldless tube 4 inches in diameter, 0·14 inch thick, and 56 feet long rolled into a spiral. The gas-welded work includes a main steam-pipe 46 feet long, 34·6 inches in diameter, with several flanged nozzles; a steam diver of 39·2 inches diameter 17 feet high; a section of a sailing ship's mast, and a reservoir for compressed air at 1500 lbs. pressure, 10·8 feet long, 19·7 inches diameter, and 1 inch thick, with ends and connecting boss welded on.

The ironworks of the Meurthe and Moselle region have a prominent representative in the Blast-Furnace, Forge, and Steelworks Company of Pompey, near Nancy. In 1889 this Company made a remarkable display of ironwork as applied to architectural design, besides furnishing a large part of the buildings and the whole of the iron for the tower of 300 metres, and on the present occasion it has applied the higher geometry to decorative purposes by constructing a surface of the second order—a hyperbolic paraboloid—as a trophy, in which the ruled lines defining the surface are made of bars, rails, angles, and other sections in steel, the geometric axes being represented by an inclined and a vertical frame made of plates and joists, the latter being crowned by an open framework studded with polished railway buffers,

of foundry iron daily, which is almost entirely converted into pipes, a considerable portion being cast direct from the blast-furnace. From $3\frac{3}{4}$ to $4\frac{1}{2}$ miles in length of pipes are produced in the foundry per working day, all being cast upright, and tested by hydraulic pressure of 15 to 25 atmospheres. This exhibit also contains a model of the shaft at Arboué now being made by the Poetsch freezing process to the grey bed of ore at 140 metres deep. This is $16\frac{1}{2}$ feet diameter, requiring about 1000 tons of cast iron tubing, and will be equipped for an output of 2000 tons daily, with pumping power capable of raising 23 tons of water per minute.

The Société Métallurgique de Gorcy, makers of pit tubing for collieries and other mines, have arrayed a complete ring of tubing, 23 feet in diameter, as an arch over one of the main passages. Associated with this are the valves and burners of a Cowper stove, in which some new features are introduced.

Another excellent display of pipes is made by the Fumel Works of the Metallurgical Society of Périgord. It adjoins that of the Pont-à-Mousson Works.

The Micheville Steelworks Company, of Micheville Villerupt, have, as a principal feature of their exhibit, a tall trophy built up of curved and straight joists, somewhat resembling a church steeple. All the ores used and the intermediate products are very fully illustrated with analytical and other details. This is one of the best exhibits for study for any one wishing to obtain a general knowledge of the conditions of minette smelting quickly.

The Longwy Steelworks Company of Mont Saint-Martin send some large and heavy steel castings, including a plate roll partially finished from the ingot, a large pinion, and a considerable number of bars and sections. Among them is an extra hard steel rail of $56\frac{1}{2}$ tons tensile strength, with 18 per cent. elongation, which supported 92 tons when laid on bearings 39 inches apart, and bore an impact test of 6 cwts. falling 20 feet without breaking.

The character of the pig iron made in Lorraine is most completely exemplified in the collection shown by the Comptoir Métallurgique de Longwy. This includes a series, classified according to numbers and uses, of foundry steel-making and forge pigs, cement, bricks, paving slabs, and other slag products,



Stenay. The latter Company exhibits the model of a small converter with side tuyeres and a pocket in the neck to facilitate pouring when casting direct.

The Saut-du-Tarn Steelworks contribute an excellent collection of tools, scythes, files, and other articles, both in puddled and cast steel, made from the manganiferous, spathic, and brown ores of the Pyrenees. The works, situated at Saint-Juery, near Albi, have a disposable fall of water of about 2500 horse-power. The principal ore supply is derived from a mine about twelve miles distant, and coal and coke for smelting are drawn from the coalfields of Albi and Carnaux, which are close at hand. The crucible steel is melted in seven gas-furnaces; that for scythes and agricultural implements is mostly puddled.

Another large exhibit of steel goods for agricultural purposes is supplied by Messrs. Gouvy & Co. of Dieulouard, Meurthe-et-Moselle, including shovels, forks, plough fittings, cart tires, &c. The materials used are natural (puddled) and refined shear steel from the puddled blooms.

The principal French representatives of tin-plate manufacture are the Société de Cirages Français, owners of the well-known forges of Hennebont in Brittany, where tin-plate for the sardine packing trade is largely produced, and the Montataire Forge and Foundry Company, who have blast-furnaces and steelworks at Frouard, Lorraine, open-hearth steelworks, rolling-mills, turning and galvanising works at Montataire, about 30 miles north of Paris, and tin-plate printing and ornamenting works at Nantes, the position of the latter being also determined by the requirements of the packing trade. Montataire is of interest historically, as having been the first place in France where tin-plate was made in 1813, as well as the site of Sudré's experiments on the smelting of steel in large masses without crucibles, made in 1862, shortly before the problem was solved by the application of the Siemens furnace to the purpose by Messrs. Martin of Sireuil.

The subject of plant for iron steelworks is principally illustrated by Messrs. A. Delattre & Co. of Ferrière la Grande, Maubeuge, who have sent the roughing pair of a reversing joist or rail-mill, with 33½ inch rolls, and hydraulic rack-and-pinion gear for the setting screws, the whole being complete with the

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the ores and smelting products in nickel and cobalt, and a very large series of nickel steels made by most of the principal steelmakers in France, the details of these last being given at length in a descriptive pamphlet. Smaller exhibits of a similar character are also exhibited in the New Caledonian Pavilion, and that of the French Colonial Ministry on the Trocadero. Another exhibit covering some of the same ground is that of the "Ferro-Nickel" Company in the gallery of the main building. This contains, besides iron, nickel alloys which are considered to be preferable to pure nickel for steel-making, German silver and other copper alloys, and the original samples of nickel steel exhibited in 1889, when they were received with comparative indifference.

The principal aluminium exhibit in the gallery of the main building is that of the French Electro-Metallurgical Society of Froges, Isère, having alumina works at Gardanne and electrolytic reduction works at Froges and La Praz, where the Héroult process is used under the direction of the inventor. At the latter works, where 15,000 horse-power is disposable, the power water is carried across a river by a rivetted steel pipe 7·9 feet in diameter, passing an arch of 213 feet span without intermediate supports or bracing. This includes pure aluminium and its alloys in ingots, bars, plates, and other rolled forms, castings, and a very full series of manufactured objects. In the special electrical pavilion will be found a series of thick plates and bars of aluminium of high purity by the Alais and Lamage Company, formerly Pechiney & Co., and in the same place an application of aluminium in the place of copper for conveying a heavy electric current is shown. There are some fine examples of aluminium and aluminium-bronze castings in the main building by Mr. M. Corbin, and also by Mr. H. Partin of Puteaux, so-called Partinum metal. Among the latter are frames for 50 and 35 horse-power motors for the heavy automobile carriages or "*tracteurs*" of Messrs. De Dion Bouton & Co.

Another interesting application of aluminium shown outside the Military Pavilion on the Quai d'Orsay is a portable military bridge made for the Aluminum Commission by the Forges de Sedan from the designs of General Dumont. This is a lattice truss girder for a span of 57 feet, with three beams each in two

| Category | U.S. should take action (%) | U.S. should not take action (%) |
|-------------|-----------------------------|---------------------------------|
| 18-29 | ~85 | ~15 |
| 30-49 | ~80 | ~20 |
| 50-69 | ~75 | ~25 |
| 70+ | ~65 | ~35 |
| High School | ~70 | ~30 |
| College | ~80 | ~20 |
| Graduate | ~85 | ~15 |

1. *Chlorophyll a* and *Chlorophyll b* were determined by the method of Arar and Collins (1987) using a spectrophotometer (Shimadzu 1601) with a 10 mm quartz cuvette. The concentration of chlorophyll was expressed in $\mu\text{g mL}^{-1}$ of the sample.

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| Circumstance | Justified (%) | Not justified (%) |
|-------------------------------|---------------|-------------------|
| If someone is attacking you | 85 | 15 |
| If someone is threatening you | 75 | 25 |
| If someone is harassing you | 65 | 35 |
| If someone is insulting you | 45 | 55 |
| If someone is annoying you | 15 | 85 |

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Figure 1. The effect of the number of trials on the number of correct responses. The number of correct responses was significantly higher than the number of incorrect responses in all conditions. Error bars represent the standard error of the mean.

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1. *Journal of the American Medical Association*, 1997; 277: 1039-1043.

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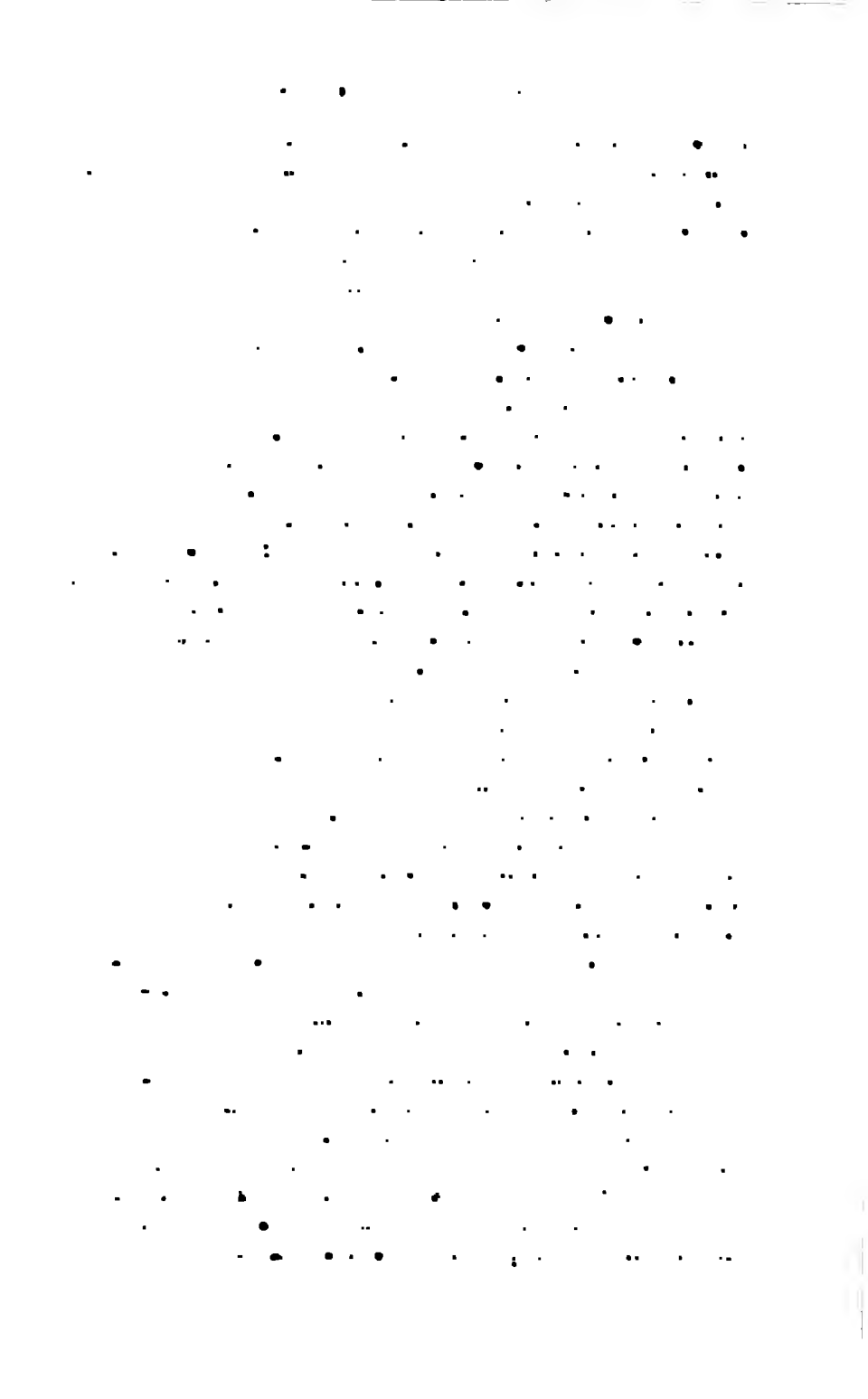
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Italy.—The principal feature in the Italian Section is the large exhibit of the Terni Steelworks Company, which occupies the larger part of the ground-floor space. In this are included a model of their principal establishment, the well-known water-power steelworks and forges at Terni, described in Sir B. Samuelson's paper in the *Journal of the Institute* (1887, No. I.), numerous examples of heavy castings for waterworks, pipes from 0·8 to 60 inches diameter, and sluice valves of $7\frac{1}{2}$ and $9\frac{1}{2}$ tons, rails and fish-plates, the cylinder covers for the engines of a large cruiser in cast steel, projectiles of all sizes up to 13·6 inches diameter, and armour-plates. The latter are of two kinds, called respectively "Terni Patent" and "Terni Special," the first being made to resist penetration without special regard to immunity from cracking, while the second, being of a more ductile character, may be penetrated at extreme velocities, but develop no surface fractures. Four specimens of each class of plate, ranging in thickness from about 3 to 6 inches, are shown with the details of penetration, velocity, &c., of the different shots marked on them, these details being further presented in a descriptive pamphlet. The pig iron used at these works is partly derived from blast-furnaces in the Val Trompia; the fuel is lignite from mines at Spoleto. Some fine examples of fossil tree trunks from these mines are exhibited, together with numerous photographs of the works. Another collection of steel castings made in the Roberts converter is contributed by the Milanese Steel Foundry Company of Milan. This contains models in steel of stem and stern-post castings executed for the Italian and other navies, the full-sized foundry patterns being shown in the Naval Pavilion. Mr. Frank Griffin of Brescia sends examples of the strong foundry iron of that district, including a large plate roll and railway or tramway wheels cast in chill.

The gallery of the Italian Section contains a fine case of aluminium goods by Mr. Claudio Zecchini of Milan, and a very complete collection illustrating the geology and mineral resources of the kingdom, made by the Royal Corps of Mining Engineers. In this the iron ores of Italy are well displayed by a series of about a hundred specimens from Elba, the Alpine and Sub-Alpine regions, Naples, and Sicily.



per minute. Adjoining this, on the south side, is a 1200-ton direct acting steam and hydraulic press of the well-known form made by Messrs. Breuer, Schuhmacher, & Co. of Kalk, with a hydraulic bar shear of a very compact form, the pressure pumps being driven by an electro-motor attached to the framing, by the same makers. A fine piece of flanging, a boiler front with two holes for furnace tubes, and a boss for the water-gauge attachment produced at one heat, is shown in illustration of the work done by the press. Other machines for flanging and deep stamping are shown by Mr. L. Schuler of Goppingen and Mr. R. Chillingworth of Nürnberg, the latter making a special exhibit of driving pulleys, either solid or built up in two or more segments, stamped out of steel-plate, which are being largely used instead of cast iron or wooden wheels. The northern side of the court is occupied by the Allgemeine Electricitäts Gesellschaft with a Riedler "express" pump driven by an electro-motor of 75 horse-power, intended to lift 240 gallons per second to a height of 900 feet, the space occupied for this combination being only about one-fourth of that required by an underground steam-pump of the same capacity. Adjoining this is a large show of electric-driven rock-drills, both of rotatory and percussive kinds, by Messrs. Siemens & Halske.

The gallery of the German Section is largely devoted to amber, but also contains several objects of great metallurgical interest, the most notable being that of the Thermo-Chemical Industry Company of Essen, illustrating Dr. H. Goldschmidt's method of reducing the oxides of chromium, nickel, manganese, and other refractory metals by combustion with finely divided aluminium, when, as a consequence of the intense local development of heat, the reduced metal, although free from carbon, melted, as also the slag, the latter being pure alumina, which is tinted with a little chromium oxide, and crystallises in the form of corundum or ruby. This being harder than natural emery, has found an application as an abrasive material under the name of "corubin." Another application of this method is to the welding of tubes or rails by the heat developed in the reduction of a mixture of oxide of iron aluminium and other substances, supplied as a mixture called "thermite," which is burned in a box surrounding the parts to be joined. Chromium and manganese of high purity are obtained by this method with great ease, and singularly enough

the latter metal, which as high ferro-manganese is readily oxidisable, seems to keep perfectly bright in the air when free from carbon. A notable advance in the knowledge of working aluminium is shown in the exhibit of Mr. W. C. Heræus of Hanau, who has discovered that within a small range of temperature, nearly but not quite at a red heat, the metal may be welded, and several examples, including tubes, funnels, and the worm of a still, are shown in illustration of the method.

The Silesian Nickel Works show specimens of nickel smelted from pimelite and schuchardite. These are indefinite hydrated silicates, somewhat like the noumeite of New Caledonia, with magnesia, alumina, and nickel oxide as bases. The maximum amount of nickel contained is 14 per cent.

One of the largest examples of welded work in the Exhibition is the gas reservoir sent by Mr. Julius Pintsch, made from steel plates supplied by the Borsig Works. This is a cylinder of 1766 cubic feet capacity, $\frac{1}{2}$ -inch plate, 59 inches in diameter, 65 feet $7\frac{1}{2}$ inches long, with $\frac{3}{4}$ -inch ends, welded by water-gas blowpipe flame, weighing 27,000 lbs. and tested to 284 lbs. per square inch. It is placed on the quay adjoining the Naval and Military building.

Great Britain.—The representation of the metallurgical industry of the United Kingdom is very small, being, so far as iron and steel are concerned, restricted to the West Riding of Yorkshire. The most prominent position is occupied by Messrs. William Jessop & Co., who send a varied collection of objects in cast steel, including wheels and pinions with straight and helical teeth, mine wheels, die blanks, sections of Swedish iron, blister and cast steel of different tempers, soft centre ingots and bars, ribbon steel for saws and pen steel, the make of the latter article being more than 1000 tons annually. Other Sheffield firms represented are Messrs. Seebohm & Dieckstahl, by a collection of sections and fractures of blister and cast steel in ingots and bars, in all the different conditions of manufacture; Messrs. Beardshaw & Son, showing a large collection of steel bars made to special sections for machine tool-cutters; Messrs. J. J. Saville & Co., crucible cast steel tools and files; and Messrs. J. H. Andrew & Co., cast steel hammers and small picks. Malleable iron is represented
1900.—ii.

by the Farnley Iron Company, who contribute a small series of forge and other working tests to show the special qualities of best Yorkshire iron. They have also a large exhibit of enamelled fireclay goods in the ceramic department. Two interesting exhibits of a retrospective character in this section deserve notice. These are the case of specimens of the first products of the Bessemer process, presented to the Institute by Sir H. Bessemer, and exhibited by the Council, and specimens and records of the first experiments made by Mr. G. J. Snelus in dephosphorising iron, together with a series of statistical and other tables, showing the present output of the basic process, which has been developed from these experiments. Mr. B. H. Thwaite and the Blast-Furnace Power Syndicate exhibit a series of drawings and documents on gas-furnaces and the use of blast-furnace gas for internal combustion engines, with a sectional model of a new form of blowing engine for blast-furnaces.

The large exhibit of Messrs. Vickers, Sons, & Maxim, contained in a separate building on the Quai d'Orsay, is mostly devoted to artillery, including 6-inch, 7½-inch quick-firing guns, a 12-inch 50-ton gun, and field-guns and equipment of various sizes, while the gallery contains a series of models of the ships built at Barrow. Besides these there are tests of locomotive crank axles and a 9½-inch tyre, and plaster casts of special nickel steel, Harveyed and other armour-plates tested at Portsmouth, the heaviest being 10 inches thick.

A series of small but representative specimens of British iron ores will be found in the gallery, forming part of the collection of British minerals sent by the Home Office. The iron ores of the Canadian Dominion are fairly well represented in the collection of the Geological Survey Department, and there is an interesting exhibit of charcoal iron, made from bog iron by the Canadian Iron Furnace Company. These ores have been worked since the end of the 17th century, and produce a metal specially suited for chilled cast railway wheels. The iron industry of India is principally represented by pig iron castings and views of the Bengal Iron Company's works at Barrakur; but in addition to this there is a large collection of iron ores and products obtained by the native smelting methods,

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and hard steel, as well as several of the famous charters and documents connected with the foundation of the Company, which were described in the Journal of the Institute on the occasion of the Swedish visit. Österby, the oldest of the Dannemora forges, shows sections of the pig iron used in the Walloon process, bars of the double bullet brand, and cast steel made from it. Walloon iron and its products are also contained in the Iggesund exhibit and that of Söderfors, these works being part proprietors of the Dannemora mines. The Fagersta collection, in addition to samples of products, contains makes of great general interest, including studies of structures due to hardening and converting by Mr. Brinell, who has succeeded in producing almost every kind of fracture in steel bars, including alternate stripes of coarse and fine grain, by varying the heat treatment; a method of determining the hardness of steel and other metals by measuring the diameter of the indent made in a plate by a hardened steel ball under a definite pressure; studies of the causes of blowholes in ingots, and a method of estimating the carbon in steel by the angle of fracture of the test-piece under the bending test. Some chrome steel is also shown, containing 1.35 per cent. chromium, made by the direct addition of chromic iron ore to the bath in the open-hearth furnace, 6.2 cwt. of ore being sufficient for the charge of 10 tons of steel.

Mr. C. W. Bildt of Stockholm sends his well-known automatic feeding arrangement for continuous and uniform supply and distribution of the fuel in gas-producers.

The iron ore regions of Lapland are represented by a geological map and some special plans of the mines of Gällivare, a model of Kiirunavaara and Luossavaara ore mountains, and specimens of the ores and rocks from these localities, all of which have been fully described in the Journal of the Institute. The amount of ore exported for Luleå in 1899 from Gällivare was 920,997. This collection is further illustrated by the excellent oil painting of Kiirunavaara under the rising (midnight) sun, which was a principal attraction at the Stockholm Mineral Exhibition in 1897. The Norbotten Mineral Improvement Company, owning the magnetic separating works at Luleå, show samples illustrating their process and the fertiliser (Wiborgh phosphate) made from the separated apatite, which contains

1. The first part of the paper discusses the importance of the study of the history of the United States. It is argued that the study of the history of the United States is essential for a full understanding of the country and its people.

2. The second part of the paper discusses the importance of the study of the history of the United States. It is argued that the study of the history of the United States is essential for a full understanding of the country and its people.

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the ductility of the rail steel, a piece is shown with one end worked up into a palm tree.

The Donetz Forges and Steelworks of Drouikovka send a somewhat similar collection to that last mentioned. This Company dates from 1891, and now has two blast-furnaces, making about 300 tons a day, three 8-ton acid Bessemer converters worked with liquid metal through a mixer of 100 tons, and two 20-ton basic open-hearth furnaces. The rail-mills are worked by a three-cylinder reversing engine of 3000 horse-power, and ingots of 42 cwts. are rolled up to 220 feet in length, giving five or six finished rails and joists, 12 inches high, up to 170 feet lengths. A similar engine drives the heavy plate and sheet mills, which are arranged on either side of it and worked alternately.

A combination of great interest is illustrated by the exhibit of the Ural Volga Company, who have lately established large steelworks and rolling-mills at Tsaritsin on the Volga, in connection with two groups of charcoal blast-furnaces at Lemeza and Aviziano Petrowski in the Southern Ural, the pig iron being carried in barges about 900 miles by the Bielaia, Kama, and Volga rivers to the steelworks, where the conversion is effected in basic open-hearth furnaces heated by naphtha residues (mazut) brought from Batum, a distance of 700 miles, by steamer on the Caspian Sea and the Volga. The barges carrying 500 to 650 tons of pig iron ore despatched from the works in a "caravan" during the summer freshet, when alone the upper part of the Bielaia River is navigable. The make of the two groups of furnaces, which draw their ore and fuel supplies from an area of about 2200 square miles, is about 2800 tons per month. The steelworks, which at present contain six 15-ton open-hearth furnaces and 14 plate, sheet, bar, and rod mills, are shown in a model as completed, the parts not yet erected being surrounded by a red line. In this two hot-blast furnaces to be erected at a future time are shown. The ultimate capacity is intended to be of about 120,000 tons of finished steel per annum. The engines in the rolling-mills, together of about 16,000 horse-power, are worked in connection with a Weiss central condenser placed in a shaft 50 feet deep, and discharging the condensed water through a walled gallery 400 feet long into the river. Three covered earthen reservoirs of a total capacity

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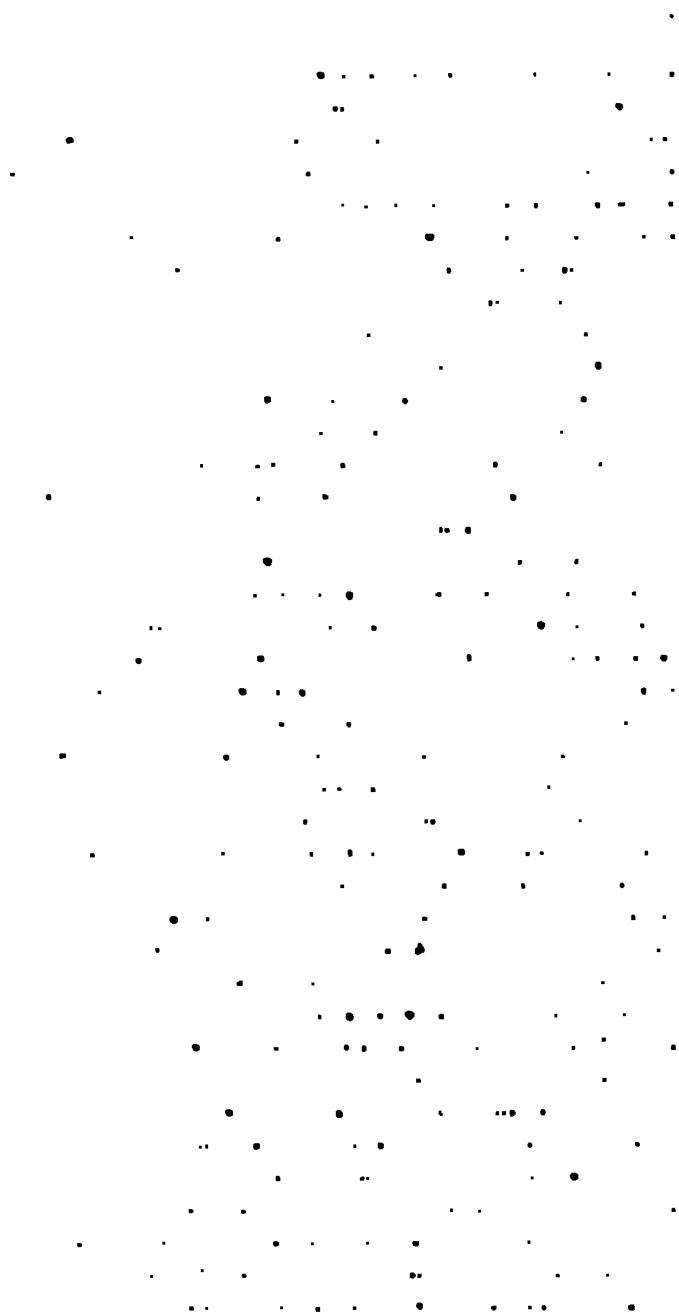
The ore contains 0·8 to 0·9 per cent. phosphorus, and when smelted with hot blast (700 degrees Cent.) gives a metal which can be cast into pots 0·2 inch thick direct from the blast-furnace.

The works of Tagil and Louina on the Demidoff estates send a small but representative collection of products from the copper and iron works centring at Nischne Tagil, which, besides being attractive, has the merit of being excellently catalogued. The works, which were noticed in the Journal of the Institute, 1898, No. I, produce about 65,000 tons of finished iron and steel and 2000 tons of copper per annum. There are also large platinum workings on the estate, producing about 30 cwt. of crude platinum per annum from sands, and in connection with these the first find of platinum in the rock was made two years since.

Another large Ural estate, the Lysva domain of Count Schouvaloff, sends, among other products, some remarkable examples of thin polished sheet iron. The strong part of this exhibit, however, is from the platinum workings, which have been greatly extended of late years, and now supply about one-third of the whole annual produce of the world.

In addition to the samples shown by the different smelting-works, there are good illustrations of iron ores from Russian Poland, the Krivoi-Rog district, and the Ural, and of manganese ores from the Caucasus, in the collections from the Department of Mines and the Geological Survey department in the gallery. Other important Russian exhibits will be found in the Military and Naval Pavilion, including a collection of chains, tubes, and armour plates from the Admiralty works, Kolpino, and the steel-testing laboratory of the Obuchoff works.

Belgium.—The Belgian Section, like that of the German Empire, contains little relating to the manufacture of iron and steel, the principal representatives of these articles having confined their exhibits to small specimens and tests, which are collectively grouped in the gallery. The central feature on the ground-floor is supplied by a pair of horizontal blowing-engines for blast-furnace use, exhibited by the Société des Ateliers de Construction de la Meuse. These are of about 500 horse-power, and two similar engines have been supplied to the Toula blast-furnaces in Russia. The Andenne Clay and Firebrick Company



blast-furnace is, however, not included in this group, but is placed with the machinery in motion. It was described in the *Journal*, 1900, No. I., p. 109, and develops 700 horse-power with blast-furnace gas and 1000 horse-power with illuminating gas.

United States of America.—In this section the largest producing establishments are scantily represented, the Carnegie Steel Company only sending a set of blue prints of one of their large blast-furnaces, and the Illinois Steel Company a sectional model of a furnace and a collection of small-sized products, mostly tests. The most prominent position is occupied by the Colorado Fuel and Iron Company, whose works at Pueblo, Colorado, smelt the magnetic and hæmatite ores of Utah with coke from New Mexico and other mountain States. It is a comparatively new establishment, but has developed rapidly, and now produces $1\frac{1}{2}$ million tons of coal, 950,000 tons of coke, 900,000 tons of iron ore, and 200,000 tons of finished steel, which, when the further extensions now in progress are completed, will be increased to 550,000 tons. The samples exhibited consist principally of rails and fish-plates, which are accompanied by a large series of maps and views of the different works and mines. The American Tinplate Company make a very full display of tin and terne plates of all kinds, together with the boxes used, and statistics of the work included in the construction and of the production.

The Crescent Steel Company of Pittsburg have a remarkably fine exhibit of crucible and open-hearth steel, and, following their practice at Chicago, they have illustrated the quality of their manufacture by examples of dies, drills, and other cutting tools made from their steel borrowed from other manufacturers, which are shown with statements of the work done by each article. The melting is done in Siemens gas-furnaces, the largest of 10 holes having a capacity for 60 pots, melting on an average 100 lbs. in a heat each, the total output of six heats in twenty-four hours being 18 tons, which is the largest yield obtained as yet from a single steel melting furnace.

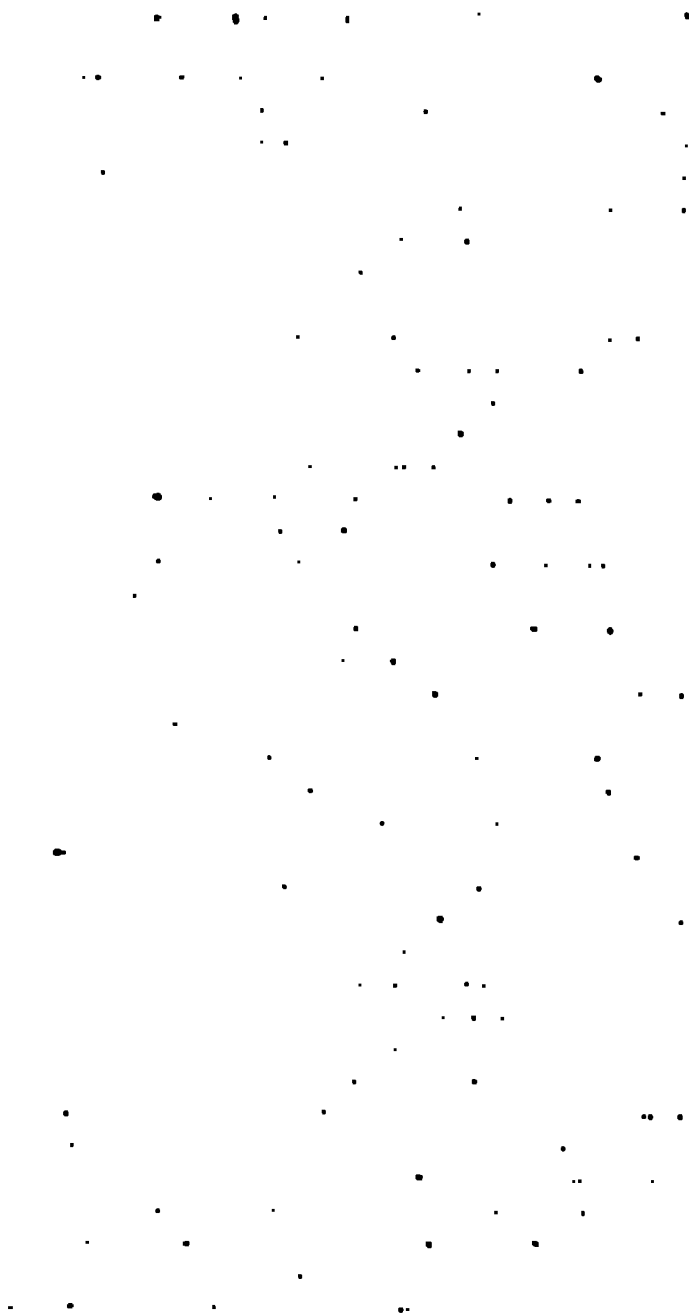
Very fine displays of wire are made by the American Wire Company, who also show draw-plates and dies of all kinds, and by Messrs. John A. Roebling's Sons & Company, who send full-sized pieces of the East River bridge cable, and a model of the bridge.

which these heavy and unwieldy objects are arranged for railway transit.

Mr. C. Später sends a large collection of products of the magnesite works at Veitsch, in Styria, including bricks of all kinds, converter bottoms, and a section showing the construction of a magnesia bottom in an open-hearth furnace, together with full descriptive catalogues in several languages.

The cutlery and scythe industry of the Austrian Alpine regions is represented in collective exhibits from Steyr, the Scythe and Sickle Makers' Union, and other manufacturers—which, however, are somewhat beyond the scope of the present paper.

The Hungarian department is very tastefully arranged, a group of miners at work being placed on one side, and another of smelters tapping a blast-furnace on the other. The principal exhibitor on the metallurgical side is the State works, having eight different establishments in several parts of the country, the most important those at Diosgyor and Buda-Pest in the central districts. In these about 120,000 tons of pig iron are made annually in two coke and six charcoal blast-furnaces, which is converted into wrought iron castings and steel bars and plate, as well as machinery, locomotives, and agricultural implements. Next in importance comes the Rimamurany and Salgo Tarjarn Company, making 1,000,000 tons of pig iron, which is nearly all converted into malleable iron and steel; and the Austro-Hungarian State Railway Company with five blast-furnaces, three at Reschitza and two at Anina, three Bessemer converters and four Siemens-Martin furnaces, making 60,000 tons of pig iron, 30,000 tons of steel, 40,000 tons of rolled bars and plates, and 15,000 tons of pottery castings, nails, tools, and railway materials. Messrs. Ganz & Co. of Buda-Pest are also considerable producers, but their principal exhibits are in the departments of machinery and railway plant. These and several smaller works make considerable displays of other products, which, however, are not of a kind calling for any special description. The most prominent object in this section is a group of the chains made at Diosgyor for the Eskutser Bridge over the Danube at Buda-Pest. The links of this are, eye bars 48 feet long, 1 inch thick,



a collection of samples and views placed on the basement floor of the Bosnian pavilion in the Rue des Nations, and they have been well described in a Memoir by Oberbergrath Poech, who has been intimately connected with their development, presented to the Mining and Metallurgical Congress in June 1900.

Spain and Portugal.—The contributions from these countries, which are mostly minerals, including iron, manganese, and copper ores, are placed in the south-west angle of the gallery, the main building adjoining each other, but in addition to these there is a very fine collection of samples of Biscayan ores, with a map and numerous views of the mines exhibited by the Circulo Minero de Bilbao, placed in the open arcade on the garden side adjoining the Buda-Pest bridge chain. In the gallery is a fine relief model of the Sommorostro mines (Franco-Belgian Company's). Spanish iron metallurgy is represented by the Compania de Asturias of La Felguera in Leon, who send a series of pipes, cast steel wheels, perforated steel sheets for coal screens, and a large and highly ornamental bronze bell, by the Fabrica de Miéres in the same province. The latter Company works a large group of collieries, producing 235,000 tons of coal annually, and two groups of blast-furnaces and forges making wrought iron and steel from local siliceous ores with some admixture of softer minerals from Bilbao. There are also works for the treatment of realgar (sulphide of arsenic), containing a small amount of mercury, the latter being recovered as metal and the former sold as refined orpiment. A very fine series of the products of these works, together with illustrations of work done by the attached bridge-building and engineering department, is contained in a special building in the open court on the west side of the Invalides building, with the bronze and iron castings from La Felguera, adjacent to it.

After a hearty vote of thanks to Professor Bauerman, the meeting was adjourned till Wednesday, 19th September, when the following paper was read :—

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showed that metals could be separated from their combinations by combustion with aluminium. Bunsen, Tissier, Michel, Beke-toff, Rose, and others, not forgetting our own Dr. Percy, made experiments which in the aggregate demonstrated the reducibility of metals from their chlorides, fluorides, sulphides, oxides, and other compounds by means of aluminium. These observations were only carried out on a small scale, and were effected by crucibles placed in a small furnace, the reactions being often violent enough to scatter the contents of the same. In recent times Claude Vautin in London carried out an important series of experiments, wherein he showed that a long series of metallic oxides were reducible by aluminium. In his case also the reagents were heated by means of a crucible placed in a coke furnace. Again Messrs. Greene and Wahl of Philadelphia have for some years been producing pure manganese on a commercial scale by dissolving manganese oxide in molten cryolite and adding metallic aluminium thereto. Some very interesting laboratory experiments, showing the possibility of producing pure iron by reducing ferrous oxide with aluminium, were brought before this Institute at its Birmingham Meeting on August 21, 1895, by one of our Members of Council, whose services to the metallurgy of iron and steel have been of the most valuable kind—I allude to Robert Abbott Hadfield; and on March 15th in the same year our President, Sir William Roberts-Austen, gave a brilliant demonstration before the Royal Institution upon the “Reduction of the Rarer Metals from their Oxides,” on which occasion several of the rarer metals were produced in some quantity by reduction with aluminium in a manner which appeared almost magical. Among other valuable investigations since then have been those of Moissan in producing aluminium alloys by the addition of metallic oxides to a bath of molten aluminium; and those of Kupelwieser and Matignon in determining the calorific effect of certain reductions with aluminium; and also the researches of Helouis in reducing vanadium, Duboin and Gauthier in reducing boron and silicon; and the interesting experiments of Francke, wherein he showed the reducibility of phosphorus from sodium phosphate by treatment with aluminium.

The researches of Vautin with the oxides led Dr. Goldschmidt to make further experiments, with the object of discovering a

covered by a thick coating of alumina slag. The light emitted by the reaction is so intense that the eyes require the protection of dark glasses. On pouring off the slag, the temperature of the underlying liquid iron can be tried by pouring the same on to a mild steel plate, or along the side of a mild steel bar, when it will be seen that the hot iron cuts its way through with ease. Pyrometer experiments with the

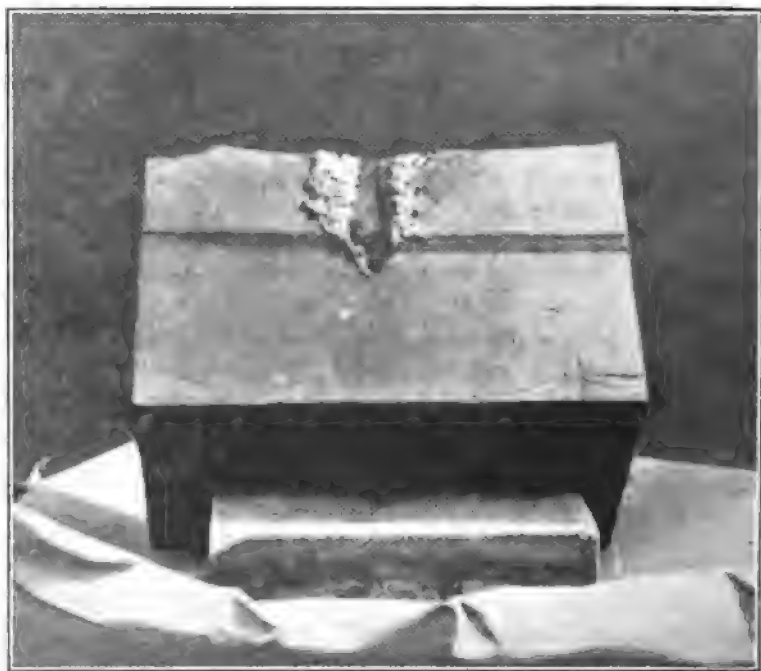


FIG. 1.—Block of steel, 10 in. thick, placed on edge, and partially molten through by the action of intensely hot fluid reduced iron.

Wiborgh thermophone have established the temperature reached in the operation at about 2900°C. to 3000°C. , that is to say, 1000°C. more than that reached during the hottest period of the Bessemer blow. In the case of the reduction of chrome from its oxide by this method, the temperature of 3000°C. is certainly reached, a temperature hitherto obtainable by the electric arc alone.



of the Goldschmidt process as applied to the production of certain metals and alloys of interest to the makers of steel and other material. In the first place, I will take the production of pure carbonless chrome and manganese.

The oxides of chrome and manganese are reduced to the pure carbonless metals in the following manner:—The oxide of the metal to be reduced is well mixed with aluminium. Some of the mixture is placed in a suitably lined crucible or tank and combustion started in the manner already described. In the same degree as the reaction proceeds, further additions of the mixture are made. In consequence of the intense heat of the reaction, there is a separation out of the pure metal in the liquid state, a result hitherto obtainable in the case of chrome by the electric arc alone, the liquid metal being covered by a slag of alumina. The reaction can be made a continuous one by providing two tap-holes, one for the metal and one for the slag. As the reaction is a very quick one, it is possible with only a moderately sized crucible to oxidise 1 to 2 kilos. of aluminium per minute, and as the products of combustion are almost non-gaseous, the reaction continues with wonderful smoothness. It is in this way possible, with quite a small floor-space and in a very short time, to produce a large quantity of metal. It is important to observe that the metal can be produced free from aluminium by providing that a small excess of oxygen is present, and also, that as aluminium is free from carbon, the metals thus produced also contain no carbon. This pure chrome is almost incorrodible, and possesses also very valuable electrical properties, but I shall only more nearly explain its value for the steel-melter.

As is well known, chrome is used for alloying with steel in the form of a high per cent. ferrochrome. These ferrochromes are distinguished by a high carbon content. This very fact limits, in cases, the amount of chrome that can be added, but by using a carbonless chrome the limits are accordingly increased. For some months at Essen and at the St. Michel de Maurienne Works, Savoy, such carbonless chrome has been made and sold for the production of chrome steel for armour plates and armour-piercing projectiles.

The manufacture of carbonless manganese is accomplished in

pieces to be welded. There is then placed round the part to be welded, but separated from it by a fixed distance, a form made of thin iron sheeting, supported by being packed round with moulding sand. The aluminium-iron-oxide combustion is then effected in a crucible of fitting size, and the contents of the crucible poured into the form. As soon as the part to be welded has taken up sufficient heat, the weld is accomplished by pressing the two parts together by means of a suitable clamping arrangement.

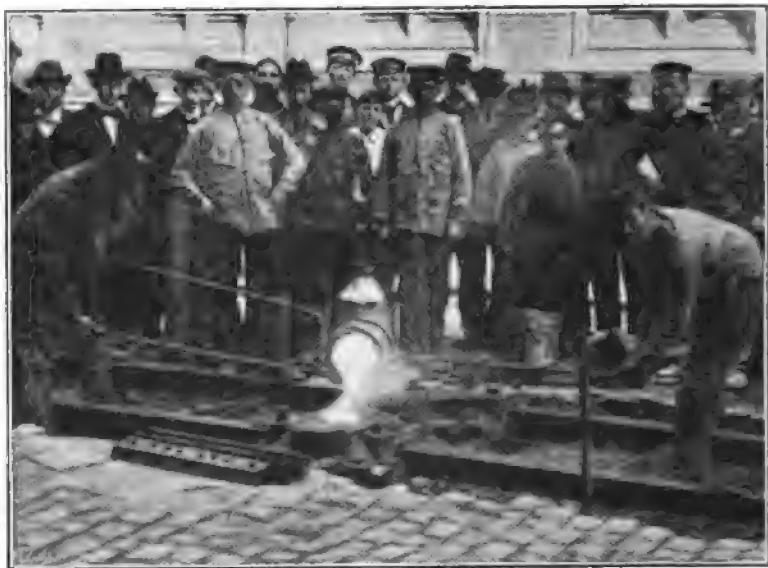


FIG. 3.—Rail-welding *in situ* for an electric tramway in Brunswick, May 1900.
(From a photograph.)

It stands to reason that inasmuch as we require different degrees of heat for the various purposes to which the aluminium-iron-oxide reaction can be put, we can regulate the mixture in such a way as to obtain a greater or less heat from the oxidation of the aluminium. For example, we do not require the same temperature in heating or welding which we would for the reduction of the refractory metals. To this end we can dilute the iron oxide with sand, or magnesia, or lime. For the lower



slag is liquefied, and a regulus of metal formed beneath. In practice, however, it is better to use a high temperature reaction, taking for the lower temperature operations so much less of the reagents. Dr. Goldschmidt has found that two aluminium-iron-oxide mixtures serve for most purposes, and at the works of the Chemische Thermo-Industrie in Essen the manufacture

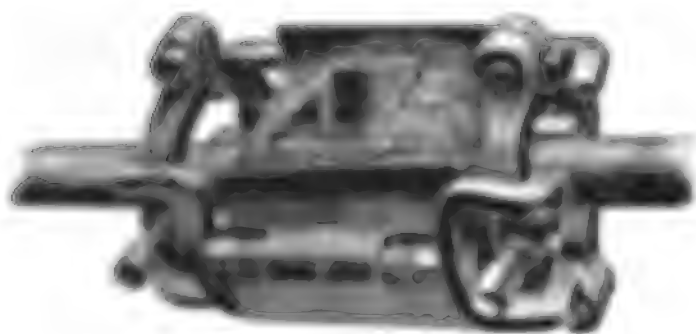


FIG. 6.—Casting form ready for filling for welding tubes in the vertical position.

of these on a large scale has been for some time in progress. To these mixtures the name Thermit has been given, the one used for welding is called Thermit P., and that used for the production of a pure iron or steel at the highest temperatures is called Thermit R., and the composition of these mixtures has been patented.

Careful experiments have been made with a view to deter-

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prevents this. At the end of the reaction in the crucible there are two fluid layers, below the fluid iron and above the light fluid alumina. On emptying the crucible, the slag pours off first, and congeals in a thin layer on the cold surfaces of the sheet iron form and the material to be welded; the remainder of the slag and the whole of the iron poured out remain for some time fluid between the congealed linings of slag, which thus protect the form and weld from fusion. Two welding processes accomplished by this method I shall now proceed to describe more particularly. In the first place, I shall note the welding together of rails for electric, tram, and small railways. Figs. 2 and 3 will give you a close idea of the arrangement for welding in the case of heavy-section tram rails.

The rails which Mr. Cooper and myself saw welded were 7-inch girder rails. A good joint having been made between the two ends, strong clamps were then secured to the rails, some 9 or 10 inches from the joint, and connected with each other by means of a strong bolt on each side of the rail. The sheet iron form was then brought round the part to be welded, and backed round with fireclay. The reaction was then started in a crucible capable of taking 15 kilos. of the aluminium-iron-oxide mixture (thermit P), and at the end of the reaction, which lasted about a couple of minutes, the contents of the crucible were poured into the sheet iron form surrounding the joint, care being taken that the slag made first contact with the cold surfaces. After waiting another couple of minutes, the rail ends were judged to be sufficiently heated, and a few turns of the nuts on the tension-bolts were given equally and simultaneously, and the weld effected. An important feature about this welding process is that the layer of slag or corundum which first forms round the part to be welded also protects the joint from oxidation. After the welding, the solidified mass can be knocked away by a few light blows from a hammer; but, as a rule, it is better to allow it to remain on for some time, so as to allow of a more gradual cooling of the rail-joint. On knocking away the mass, it was seen that the sheet iron form was so little damaged that it could be used over and over again.

With regard to the comparative cost of the joint as compared with a fish-plate joint, Dr. Goldschmidt has got out some figures

against that of welding by electricity, it is hard to find common ground for a comparison, as the number of cases where electricity is sufficiently available and its use expedient is necessarily limited, and as far as I know, no comparison has been attempted. It is to be remarked that the fish-plate joint and copper strip connection has hitherto formed the standard practice for electric railways in all countries.



FIG. 10.—Shows welded tubes burst in the direction of their length by being hammered flat whilst the welded portion remains intact.

In order to give you a clearer idea than any words of mine can convey as to the speed and ease with which the rail-welding, as witnessed by Mr. Cooper and myself, was accomplished, I have prevailed upon Dr. Goldschmidt to kindly demonstrate the same to you at the conclusion of this paper by welding together before you in this room, without risk or danger of any kind, two short lengths of heavy girder rails.



gation, and a test of the unwelded material gave a breaking load of 22.73 tons per square inch with 15 per cent. elongation.

Figs. 10 and 11, taken from photographs, show further tube tests, showing the welded part intact after a flat hammering which has caused the rest of the tube to crack, and a welded tube bent round the weld without harm to the same.

In the new works of the Chemische Thermo-Industrie in Essen, the steam service pipes are all welded together on this system, and we were informed that this had proved a consider-



FIG. 12.—Repairing of a defective steel casting, showing piece cast on

ably cheaper method of joining the pipes than the use of flanges and bolts.

Repairs were easily effected by cutting out the defective portion of the steel or iron tube and welding a new piece in position. In the same way junction and expansion tubes could be introduced where necessary. It would thus seem that the process should prove of considerable utility in the construction of many kinds of tube installations where, from one reason or another, the flanged joint is not perfectly reliable or convenient.

As before explained, the weld is protected from any destruc-

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plate which has been thickened up to $2\frac{1}{8}$ inches by this method. Figs. 12 and 13, which are taken from photographs, show, in the first place, a steel cylinder with a defective place on the flange which has been filled up with the steel produced by thermit R, and secondly, a spur-wheel with broken teeth, showing the rough portion re-cast from thermit in the one case, and the machined portion in the other.

I regret that I have not yet been able to complete certain investigations I have entered upon to determine the mechanical and other properties of this alumino-genetic iron. Micro-

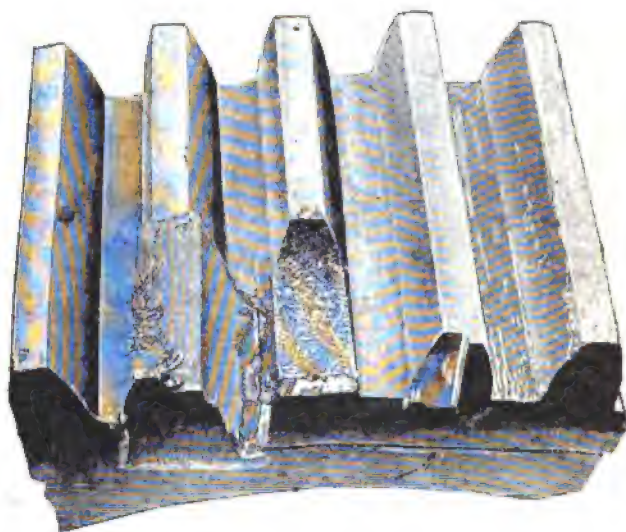


FIG. 13.—Spur-wheel with broken teeth, showing machined and unmachined cast on new portions.

structure investigations would doubtless prove interesting as well, but I hope to be able to include some of them later on in the Proceedings of the Institute. I hope, however, that this account of the heat-producing properties of thermit, and the uses to which it can be put, will induce some of you to take up some of these interesting experiments for yourselves. I think it will be clear from what I have related, that two new uses for aluminium have been called into existence for the benefit of industry, both of which rest upon the, as yet,

DISCUSSION.

The PRESIDENT stated that the experiments showed how wonderfully quickly the whole aluminium-iron-oxide reaction proceeded.

The PRESIDENT then invited discussion.

Mr. J. E. STEAD, Member of Council, asked if the metals produced by reducing the oxides were free from aluminium? He thought this process was admirably adapted for making quantities of alloys such as any chemist might wish to experiment upon, but it was very important that the alloys should be absolutely free from the aluminium.

Sir LOWTHIAN BELL, Bart., Past-President, thought this process might have another valuable application to those already mentioned by Mr. Lange. The Electric Department of the Post-Office was, and he had no doubt still was, most desirous to obtain iron absolutely free from carbon. The smallest trace of carbon was enough to convert the iron they used into a permanent magnet which interfered with its sensibility in transmitting messages, causing considerable waste of time; and it was possible that the iron free from carbon might fulfil the conditions that Sir William Preece was labouring after, and unsuccessfully, for some time.

Mr. EDWARD RILEY said the steel made now was practically free from carbon. The North-Eastern Steel Works made the rail for the Central Railway in London, and the guaranteed condition was that the conductivity was to be equal to one-seventh that of copper, and they succeeded in making a steel equal to that practically free from carbon. He should like to ask Mr. Lange about the peculiar smell caused by the experiment in the room. At first it seemed like an arsenic, but it might be hydrocarbon. They might possibly remember that many years ago the late Mr. Robert Mushet laid very great

1. The first part of the paper is devoted to a general
discussion of the problem. It is shown that the
problem is of great importance and that it has
not been completely solved. The author then
presents a new method for solving the problem.
This method is based on the use of the
variational principle. It is shown that this
method is very simple and that it can be
applied to a wide range of problems.

2. In the second part of the paper, the author
applies the new method to the problem of the
motion of a particle in a magnetic field. It is
shown that the method is very effective and
that it can be used to calculate the
trajectory of the particle. The author then
presents some numerical results and compares
them with the results obtained by other
methods.

3. In the third part of the paper, the author
discusses the problem of the motion of a
particle in a magnetic field. It is shown that
the method is very effective and that it can
be used to calculate the trajectory of the
particle.

4. In the fourth part of the paper, the author
discusses the problem of the motion of a
particle in a magnetic field. It is shown that
the method is very effective and that it can
be used to calculate the trajectory of the
particle. The author then presents some
numerical results and compares them with
the results obtained by other methods.

In the case of the uranium, he forgot whether they could reduce the oxide. At any rate, he had failed to get coherent matter, and he had also failed with titanium, mainly because it had such an attraction for nitrogen, that unless exceeding care were taken, it combined with the nitrogen of the air. The experiments were of the greatest possible interest, and no one was more sorry than he was that they could not be carried out in that room with safety under the present conditions.

Mr. LANGE, in reply, said that they could see samples in the Exhibition of most of the metals which had been reduced by this process, as had been stated by Mr. Snelus. The exhibit that Mr. Snelus had referred to was that of Dr. Goldschmidt's, and therefore, as a continuation of all that they ought to have seen in that room, it would be found very interesting. In that exhibit they would find the results of a large number of experiments, including some similar to what they had hoped to show to-day. There they would see welded tubes, welded girder rails, and the thickening up of plates by the pouring on of reduced metal, and test-pieces and broken tubes showing the strength of the material, and also pure manganese and chrome in large masses, and also samples of almost all of the metals which had been reduced by this process. The question asked by Mr. Riley in respect of the titanium had been answered by Mr. Snelus. With regard to the smell in the room, which Mr. Riley asked about, he had noticed the same thing himself in experiments with this mixture, and he felt sure that this curious smell was due to some hydrocarbon, or even a sulphur compound; but what it was he did not know. With regard to the process, it was yet very new, and they had to further investigate the process both chemically and mechanically, and experiments of great interest were still going on. Mr. Foster had asked whether fine aluminium and aluminium turnings mixed would do instead of having all the aluminium in a fine state of division. Well, he did not think that the aluminium turnings would do, because it was perfectly essential that the heat should be developed in the shortest possible time, otherwise they would not get the temperature, and they must have the most exact mixture of oxide and aluminium, and therefore both had to be in a fine state of division. He might refer to one ex-

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1. The first group of variables includes the following:

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duced on a large scale by the basic open-hearth process, and very cheaply, whilst with the process under review no purer iron could be produced on a commercial scale, owing to the difficulty in finding sufficiently pure iron oxide and also crucible lining material, having regard to the intense reducing power of aluminium. In Mr. Hadfield's Birmingham paper, alluded to in the opening of my paper, there are described certain laboratory experiments which had as their object the production of pure iron by reducing specially prepared pure oxide and oxalate of iron with aluminium. An iron of between 97·50 per cent. and 97·75 per cent. purity was obtained at a cost of about 1s. 6d. per pound. This percentage of purity attracted the attention of Dr. H. Wedding of Berlin, who wrote to draw attention to the fact that this iron was not so extraordinarily pure, considering that the iron used by the Iron Alloys Committee of one of the German societies for the preparation of nickel iron alloys had been made in quantity in an ordinary basic open-hearth furnace by F. Krupp at Essen, and was of 99·71 per cent. purity. It would appear, therefore, that the basic open-hearth furnace, melting pure materials, would always be a cheaper producer of pure iron than any reduction process by aluminium.

The PRESIDENT said they would all give a hearty vote of thanks to the author of this very valuable paper. There was one very interesting feature of the reaction, as was mentioned by Mr. Lange, viz., the absence of non-gaseous products, and the oxides produced as slags had many remarkable characteristics.

The following paper was then read:—

THE JOURNAL OF THE AMERICAN MEDICAL ASSOCIATION

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THE JOURNAL OF THE AMERICAN MEDICAL ASSOCIATION
PUBLISHED WEEKLY
CHICAGO, ILL., MAY 1, 1919
Vol. 34, No. 19

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PUBLISHED WEEKLY
CHICAGO, ILL., MAY 1, 1919
Vol. 34, No. 19

and steel, for among the twenty-two problems which were presented by the parent Association, problem No. 1 asked the American Section to co-operate in establishing "international rules and specifications for testing and inspecting iron and steel."

Under authorisation of the Executive Committee, the American Branch of Committee No. 1 was increased to thirty-four members, half of whom were engineers, professors in technical schools, consumers of steel, or delegates from scientific societies, and half representatives from the leading American manufacturers of the various kinds of iron and steel.

This Committee has held frequent meetings since March 9, 1899. Its sub-committees have collected and tabulated the requirements of existing American specifications which have been used as a basis in framing the ten proposed American standard specifications, which were discussed, revised, and finally endorsed as representative of the best American practice, by letter ballot, practically all members voting in favour of the specifications. Having had the benefit of criticism from leading technical societies and journals during the summer, they will be brought before the International Association for Testing Materials at its third annual meeting next October, for discussion and adoption, perhaps after some revision, as American Standard Specifications. They will then be forwarded to the chairman of the International Committee No. 1 of the International Association for Testing Materials, with the tables of existing specifications on which they were based.

If each national branch of Committee No. 1 proceeds on these lines, international specifications, at the next Congress of the International Association for Testing Materials, may be realised, but even if this is found impossible, much will have been accomplished, in each country, by the adoption of national standards.

As these specifications embody the results of over a year's conscientious work by a Committee of prominent Americans, representing all interests, the writer was asked to prepare for this meeting of the Institute a critical review of the requirements contained therein. A comparison of the nine specifications for steel may be most conveniently accomplished by using the

following clause from the specification for steel rails constitutes the exception above referred to:—

“The entire process of manufacture and testing shall be in accordance with the best current practice, special care being given to the following instructions:—Ingots shall be kept in a vertical position in pit-heating furnaces; no bled ingots shall be used; sufficient material shall be discarded from the top of the ingot to insure sound rails.”

As far as American practice is concerned this clause is unnecessary, as the details of the process specified are carried out in the everyday practice of every rail-mill in the United States.

If an engineer prefers acid rather than basic open-hearth steel, it is perfectly proper for him to so specify. Of course, he restricts competition and increases the cost of his structure. If he desires the finished material annealed, it is also proper for him to so define the process of annealing, that it shall not include a slow cooling from the initial temperature of casting or rolling or forging. It is, however, plainly outside of the territory over which he has jurisdiction for him to specify the composition or character of the raw materials, or the proportion of scrap which may be used, or any other details of manufacture. Furthermore, conscientious inspection, under specifications governing the details of nearly every step in the manufacture, is utterly impossible within the cost of inspection allowed by the engineer or contractor. The requirements of a specification governing the details of the process of manufacture are therefore often openly ignored by both manufacturer and inspector.

2. *Annealing*.—Reference to this important process for the removal of the internal strains unavoidably present in such finished material as steel castings, steel forgings, eye-bars, and plates has been to a large extent omitted in the steel specifications under discussion, so as to leave the customer free to add it to the requirements called for, if he desires a better material and is willing to pay the additional cost; or free to definitely specify that his material shall *not* be annealed, in case he fears, as is unjustly claimed by some engineers, that the annealing process will be used by the manufacturer to bring an inferior material within the physical requirements specified. As before stated, it is perfectly proper for the engineer to specify that slow cooling

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TABLE II.—Required Limits in the Chemical Composition of Steel.

| Specification for | Carbon per Cent. | Manganese per Cent. | Silicon per Cent. | Phosphorus not over per Cent. | Sulphur not over per Cent. | Nickel not over per Cent. |
|--|------------------------------|---------------------|-------------------|-------------------------------|----------------------------|---------------------------|
| Steel castings | Not over 0.40 | ... | ... | 0.08 | ... | ... |
| { Ordinary castings | ... | ... | ... | 0.05 | 0.06 | ... |
| { Tested castings | ... | ... | ... | 0.06 | 0.06 | ... |
| Steel axles | ... | ... | ... | 0.06 | 0.06 | ... |
| { Car, engine truck, and tender truck | ... | ... | ... | 0.06 | 0.06 | ... |
| { Driving wheel (carbon steel) | ... | ... | ... | 0.04 | 0.06 | ... |
| { Driving wheel (nickel steel) | ... | ... | ... | 0.10 | 0.10 | 3.75 |
| { Of soft or low carbon steel | ... | ... | ... | 0.06 | 0.06 | ... |
| { Of carbon steel, not annealed | ... | ... | ... | 0.04 | 0.04 | ... |
| { Of carbon steel, oil-tempered or annealed | ... | ... | ... | 0.04 | 0.04 | ... |
| { Of nickel steel, oil-tempered or annealed | ... | ... | ... | 0.05 | 0.05 | 3.75 |
| Steel tires | ... | Not over 0.80 | Not under 0.20 | 0.10 | ... | ... |
| { Structural steel for buildings, including rivets | ... | ... | ... | 0.08 | 0.06 | ... |
| { Structural steel for bridges and ships, including rivets | ... | ... | ... | 0.06 | 0.06 | ... |
| { Acid-open hearth | ... | ... | ... | 0.06 | 0.06 | ... |
| { Basic open-hearth | ... | ... | ... | 0.04 | 0.04 | ... |
| Open-hearth boiler plate and rivet steel | ... | 0.30-0.60 | ... | 0.06 | 0.05 | ... |
| { Flange or boiler steel | ... | 0.30-0.50 | ... | 0.04 | 0.04 | ... |
| { Fire-box steel | ... | 0.30-0.50 | ... | 0.10 | 0.04 | ... |
| { Extra soft steel | Not over 0.15 | 0.30-0.60 | ... | 0.10 | ... | ... |
| Steel splice bars | 50 lbs. to 59 + lbs. | 0.70-1.00 | Not over 0.20 | 0.10 | ... | ... |
| { 60 lbs. to 69 + lbs. | 0.35-0.45 | 0.70-1.00 | Not over 0.20 | 0.10 | ... | ... |
| { 70 lbs. to 79 + lbs. | 0.38-0.48 | 0.76-1.05 | Not over 0.20 | 0.10 | ... | ... |
| { 80 lbs. to 89 + lbs. | 0.40-0.50 | 0.80-1.10 | Not over 0.20 | 0.10 | ... | ... |
| { 90 lbs. to 100 lbs. | 0.43-0.53 | 0.80-1.10 | Not over 0.20 | 0.10 | ... | ... |
| Steel rails of weight per yard specified | 0.45-0.55 | 0.80-1.10 | Not over 0.20 | 0.10 | ... | ... |

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1. *Phragmites australis* (Cav.) Trin. ex Steud.

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Figure 1. The effect of the number of trials on the number of correct responses. The number of correct responses was significantly higher than the number of incorrect responses in all cases. The number of correct responses was significantly higher than the number of incorrect responses in all cases. The number of correct responses was significantly higher than the number of incorrect responses in all cases.

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Figure 1. The effect of the concentration of the *Agrobacterium* suspension on the transformation efficiency of *Agrobacterium* strains. The *Agrobacterium* strains were grown in the medium containing 100 mg/l of tetracycline. The cells were harvested at the stationary phase and adjusted to the concentration of 1×10^8 cells/ml. The cells were then diluted to the concentrations of 1×10^7 , 1×10^6 , 1×10^5 , 1×10^4 , and 1×10^3 cells/ml. The cells were then used for the transformation of *Agrobacterium* strains. The transformation efficiency was determined by the number of transformants per 10^6 cells. The results are shown in Table 1.

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TABLE III.—Required Limits in the Physical Properties of Steel.

| Specification for | Tensile Strength. Tons per Square Inch. | Yield Point. Tons per Square Inch. | Elongation per Cent. See Note (c). | Contraction of Area per Cent. | Bending Test. D=Diameter. T=Thickness. |
|--|---|---|--|--|--|
| Steel castings | <div> <div>Ordinary castings</div> <div> <div>Tested castings</div> <div> <div> <div>Hard</div> <div> <div>Medium</div> <div>Soft</div> </div> </div> </div> </div> </div> | <div> <div>17-08</div> <div>14-08</div> <div>12-08</div> </div> | <div> <div>15</div> <div>18</div> <div>22</div> </div> | <div> <div>20</div> <div>25</div> <div>30</div> </div> | <div> <div>90° D=2 T</div> <div>120° D=2 T</div> </div> |
| Steel axles | <div> <div>Car, engine truck, and tender truck</div> <div> <div>Driving axles (carbon steel)</div> <div> <div>Driving axles (nickel steel)</div> </div> </div> </div> | <div> <div>17-85</div> <div>22-32</div> </div> | <div> <div>18</div> <div>25</div> </div> | <div> <div>45</div> </div> | <div> <div>180° D=T</div> <div>180° D=3 T</div> </div> |
| Steel forgings | <div> <div>Soft or low carbon steel</div> <div> <div>Carbon steel, not annealed</div> <div> <div>Carbon steel, annealed</div> <div> <div>Carbon steel, oil-tempered</div> <div> <div>Nickel steel, annealed</div> <div>Nickel steel, oil-tempered</div> </div> </div> </div> </div></div> | <div> <div>12-95</div> <div>16-74</div> </div> | <div> <div>28</div> <div>18</div> </div> | <div> <div>35</div> <div>30</div> </div> | <div> <div>Physical qualities vary with diameter of the forgings. (See Note c.)</div> </div> |
| Steel tires | <div> <div>Passenger engines</div> <div> <div>Freight engines and car wheels</div> <div>Switching engines</div> </div> </div> | <div> <div>44-64</div> <div>49-11</div> <div>53-57</div> </div> | <div> <div>12</div> <div>10</div> <div>8</div> </div> | <div> <div>26</div> </div> | <div> <div>180° Flat</div> </div> |
| Structural steel for buildings | <div> <div>Rivet steel</div> <div> <div>Medium steel</div> </div> </div> | <div> <div>13-39</div> <div>15-62</div> </div> | <div> <div>22</div> </div> | <div> <div>22</div> </div> | <div> <div>See Note (b)</div> </div> |

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safe index of ductility. In the present state of the art it is a safe check, where only minimum tensile strength is required, against the use of a steel too high in carbon or other hardening elements for the purpose intended. The ease with which the determination can be made on rolled material makes it valuable and desirable in the commercial testing of large output, where rapidity as well as accuracy of testing is demanded.

8. *Contraction of Area.*—The percentage of contraction of area is included in the requirements for castings, axles, and forgings where the tensile strength is determined on a turned test specimen. It was omitted from the specification for tires, where a turned specimen is also used, because it was considered an unnecessary requirement in testing the high carbon steel used in this case, as the tires are very seldom annealed.

The value of this determination as an index of the quality of steel is fully appreciated by those who have made a comparative study of microscopical structure, and the accompanying physical properties as determined on turned specimens. The uniformly fine-grained micro-structure, only attained when a proper heat treatment has given to the steel the best physical qualities, is invariably accompanied by the highest percentage of contraction of area obtainable with any given class of steel.

9. *Bending Tests.*—No bending test is included in the specifications for axles, tires, and rails. The bending tests required in the other six steel specifications are compared in Table III., where the letter "T" denotes the thickness of the bending test specimen, and the letter "D" the diameter of the piece around which it is bent. For open-hearth boiler plate and rivet steel the bending tests given in the table are required after the specimen has been quenched as well as in the natural condition. In all other cases the cold bending tests given in the table are to be made on untreated bending specimens cut from the finished material.

The cold-bending test is a valuable indication of the structure of the metal, and in this respect bears a close relation to the contraction of area. The two are indications of the same quality in the steel, namely, its capacity for cold flow. A steel having a high contraction of area will always stand severe cold bending, and, conversely, a steel capable of severe cold bending will

sample taken from a broken tensile specimen shall not show any single defective flaw or slag streak more than a quarter inch long in any of the three fractures obtained by carrying out the test as described in paragraph 24.

12. *Percussive Test*.—This test is only specified for large steel castings. It consists in suspending and hammering the casting at numerous places. The test is made to locate any cracks, flaws, defects, or weakness in the casting.

E. THE TEST-PIECES AND METHODS OF TESTING SPECIFIED.

13. *Tensile Specimens*.—The standard turned test specimen, half an inch diameter and 2-inch gauged length (see Fig. 1) is prescribed in the specifications for steel castings, axles, forgings, and tires.

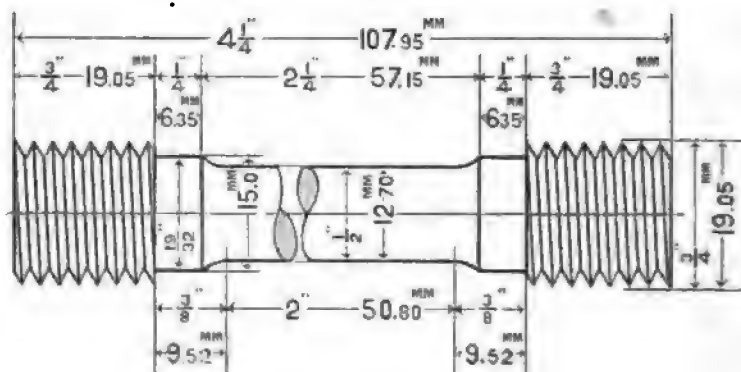


FIG. 1.

Much may be said in favour of the general adoption of this test specimen of a gauged length of four diameters for the commercial testing of these four classes of steel. With axles and all steel forgings a much shorter prolongation of the forging is required for a longitudinal specimen of the above length than for a test specimen of 8-inch gauged length. The shorter specimen therefore requires the manufacturer to consign much less good metal to scrap, an item of considerable importance to the customer in the case of forgings of large diameters.

Furthermore, less time and labour is expended in cutting out

1. The first part of the document discusses the importance of maintaining accurate records of all transactions and activities. It emphasizes that proper record-keeping is essential for transparency and accountability, particularly in financial matters.

2. The second part outlines the specific procedures for recording transactions. It details the steps involved in identifying, documenting, and verifying each transaction, ensuring that all relevant information is captured and stored securely.

3. The third part addresses the challenges associated with record-keeping, such as data loss, corruption, and unauthorized access. It provides strategies to mitigate these risks, including regular backups, secure storage solutions, and strict access controls.

4. The fourth part discusses the role of technology in enhancing record-keeping processes. It highlights the benefits of using digital tools and software to streamline data collection, storage, and retrieval, while also noting the need for robust security measures.

5. The fifth part concludes by emphasizing the ongoing nature of record-keeping and the importance of continuous monitoring and improvement. It encourages organizations to stay updated on best practices and emerging technologies to ensure their records remain accurate and reliable.

all cases where possible two opposite sides of the test specimen shall be the rolled surfaces. The three specifications further provide that rivet rounds and small rolled bars shall be tested of full size as rolled. In the specification for splice bars it is not specified whether the test specimen shall be planed parallel or of the shape shown in Fig. 2. Owing to the shape of the section of splice bars the parallel specimen can be more readily obtained. In all these necessary variations from the shape of specimen shown in Fig. 2, however, the same gauged length of 3 inches is required.

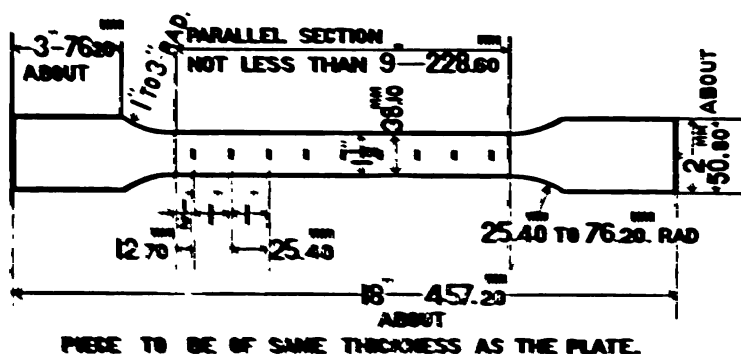


FIG. 2

The standard test specimen shown in Fig. 2 has already been so generally adopted for the commercial testing of all kinds of structural plates that argument in its favor is almost superfluous. In the present day of large quantities of structural and plate work the preparation of the many test specimens, without a delay in shipment of finished material, necessitates the adoption of a standard steel specimen which can be readily prepared in groups by special machines from the scrapings from plates of varying thicknesses. The ability to compare the physical properties of different makes of steel, a wide variety of steel, made possible by the use of the standard test specimen, forms the strongest argument in favor of its general adoption.

4. *Number of Tension Specimens.*—In the specifications for designating and testing structural steel for buildings, structural steel for bridges and ships, and splice bars, one tensile specimen from

The first of these was the discovery of gold in California in 1848. This discovery led to a great influx of people to California, and the state became a great center of population. The second was the discovery of gold in Nevada in 1859. This discovery led to a great influx of people to Nevada, and the state became a great center of population. The third was the discovery of gold in Colorado in 1858. This discovery led to a great influx of people to Colorado, and the state became a great center of population.

The fourth was the discovery of gold in Idaho in 1860. This discovery led to a great influx of people to Idaho, and the state became a great center of population. The fifth was the discovery of gold in Montana in 1862. This discovery led to a great influx of people to Montana, and the state became a great center of population. The sixth was the discovery of gold in Wyoming in 1869. This discovery led to a great influx of people to Wyoming, and the state became a great center of population.

The seventh was the discovery of gold in Utah in 1871. This discovery led to a great influx of people to Utah, and the state became a great center of population. The eighth was the discovery of gold in Arizona in 1876. This discovery led to a great influx of people to Arizona, and the state became a great center of population. The ninth was the discovery of gold in New Mexico in 1878. This discovery led to a great influx of people to New Mexico, and the state became a great center of population. The tenth was the discovery of gold in Texas in 1880. This discovery led to a great influx of people to Texas, and the state became a great center of population.

The eleventh was the discovery of gold in Oklahoma in 1889. This discovery led to a great influx of people to Oklahoma, and the state became a great center of population. The twelfth was the discovery of gold in Kansas in 1891. This discovery led to a great influx of people to Kansas, and the state became a great center of population. The thirteenth was the discovery of gold in Nebraska in 1893. This discovery led to a great influx of people to Nebraska, and the state became a great center of population. The fourteenth was the discovery of gold in Iowa in 1895. This discovery led to a great influx of people to Iowa, and the state became a great center of population.

The fifteenth was the discovery of gold in Missouri in 1897. This discovery led to a great influx of people to Missouri, and the state became a great center of population. The sixteenth was the discovery of gold in Illinois in 1899. This discovery led to a great influx of people to Illinois, and the state became a great center of population. The seventeenth was the discovery of gold in Indiana in 1901. This discovery led to a great influx of people to Indiana, and the state became a great center of population. The eighteenth was the discovery of gold in Ohio in 1903. This discovery led to a great influx of people to Ohio, and the state became a great center of population. The nineteenth was the discovery of gold in Pennsylvania in 1905. This discovery led to a great influx of people to Pennsylvania, and the state became a great center of population. The twentieth was the discovery of gold in Maryland in 1907. This discovery led to a great influx of people to Maryland, and the state became a great center of population.

material which is to be annealed or otherwise treated before use, a full-sized section of tensile test specimen length shall be similarly treated before cutting the tensile test specimen therefrom.

17. *Methods for Tensile Tests.*—None of the specifications prescribe the methods to be used for the determination of tensile strength, elongation, or contraction of area. All of the specifications in which the yield point is included in the prescribed physical properties state that the yield point shall be determined by the careful observation of the drop of the beam or halt in the gauge of the testing machine. In the specification for steel forgings, where elastic limit is required in some cases, it is provided that the elastic limit specified shall be determined by means of an extensometer, which is to be attached to the test specimen in such manner as to show the change in rate of extension under uniform rate of loading, and will be taken at that point where the proportionality changes.

18. *Test Specimens for Bending.*—As stated in paragraph 9, no bending test is included in the specifications for axles, tires, and rails. It was considered unnecessary to specify the length of the bending specimen in any case. For castings and forgings, a specimen one inch wide by half an inch thick is specified. With structural steel for buildings and for bridges and ships, and with open-hearth plate and rivet steel, it is specified that the bending specimen shall be $1\frac{1}{2}$ inches wide if possible; and further, that with material three-quarters of an inch and less in thickness the specimen shall have the natural rolled surface on two opposite sides, whereas in case of material more than three-quarters of an inch in thickness the specimen may be half an inch thick. Each of these three specifications state that bending tests on rivet rounds shall be made on full-sized specimens, as rolled. With splice bars no particular size is specified when the specimen is cut from the head of the splice bar. If preferred, the bending test may be made on an unpunched splice bar, which, if necessary, shall be flattened before testing.

19. *Number of Bending Test Specimens.*—The specifications for structural steel for buildings and for bridges and ships and for splice bars specify that one bending test specimen shall be

1. The first part of the document discusses the importance of maintaining accurate records of all transactions and activities. It emphasizes that proper record-keeping is essential for transparency and accountability, particularly in financial matters.

2. The second part outlines the various methods and tools used to collect and analyze data. This includes both traditional manual methods and modern digital technologies. The document highlights the need for consistent data collection practices to ensure the reliability of the results.

3. The third part focuses on the analysis of the collected data. It describes how statistical methods and software tools are used to identify trends, patterns, and anomalies. The document stresses the importance of interpreting the data correctly to draw meaningful conclusions.

4. The fourth part discusses the reporting and communication of the findings. It provides guidelines on how to present the data in a clear and concise manner, using appropriate visual aids like charts and graphs. The document also emphasizes the need for transparency in reporting, ensuring that all relevant information is disclosed.

5. The fifth part addresses the ethical considerations and potential biases in the research process. It discusses the importance of maintaining objectivity and integrity throughout the study, and the need to disclose any potential conflicts of interest or biases that may affect the results.

6. The sixth part concludes the document by summarizing the key points and providing recommendations for future research. It encourages ongoing monitoring and evaluation of the processes and results to ensure continuous improvement and accuracy.

7. The final part of the document provides a list of references and sources used in the research. This includes books, articles, and other relevant documents that provide additional context and support for the findings presented in the report.

8. The document also includes a section for the author's contact information and a statement of acknowledgment. This section expresses gratitude to the individuals and organizations that provided support and resources during the research process.

9. The document is signed and dated by the author, providing a formal conclusion to the report.

10. The document is reviewed and approved by the relevant authorities, ensuring that it meets the required standards and guidelines.

11. The document is distributed to the intended audience, ensuring that the findings are accessible to those who need them.

12. The document is archived for future reference, ensuring that the information is preserved and available for future research and analysis.

13. The document is updated as new information becomes available, ensuring that the findings remain current and relevant.

14. The document is used as a basis for further research and development, contributing to the advancement of the field.

15. The document is used to inform policy decisions and guide the implementation of programs and initiatives.

16. The document is used to educate the public and raise awareness of the issues being studied.

17. The document is used to promote transparency and accountability in the research process.

18. The document is used to build trust and confidence in the research findings.

19. The document is used to support the development of new theories and models.

20. The document is used to inform the development of new technologies and tools.

21. The document is used to improve the quality of the research process and the results.

22. The document is used to advance the field and contribute to the body of knowledge.

23. The document is used to inform the development of new policies and programs.

24. The document is used to support the development of new initiatives and projects.

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23. *Methods for Drop Tests.*—The drop tests required for axles, tires, rails, and castings are noted in paragraph 10. In each case a sample of the finished material ready for shipment is subjected to the test; in the case of rails it is specified that the piece tested shall not be more than 6 feet long. In testing axles and tires one is selected from each melt. In testing rails, a piece of rail is selected from every fifth blow, with provision for testing intermediate blows in case three rails from the tested blow fail. In steel castings where the drop test or test to destruction, as it is called, is substituted for the tensile test, three castings from a lot are tested, the lot consisting of all the castings from the same melt or blow annealed in the same furnace charge.

Tires are placed vertically under the drop in a running position on a solid foundation of at least ten gross tons in weight and subjected to successive blows from a tup weighing 2240 pounds, falling from increasing heights until the required deflection is obtained. Rails are placed head upwards on solid supports three feet apart. It is specified that the anvil block shall weigh at least 20,000 pounds, and that the supports shall be a part of, or firmly secured to, the anvil. Also that the tup shall weigh 2000 pounds, and that its striking face shall have a radius of not more than 5 inches. The machines in use in America vary somewhat in other non-essential details.

Axles are placed on supports 3 feet apart in such a position that the tup will strike the axle midway between the ends. The anvil must weigh 17,500 pounds and the tup 1640 pounds; the radius of supports and of the striking face of the tup in the direction of the axis of the axle must be 5 inches. The anvil is supported on twelve helical springs, which rest on a cast iron base resting in turn upon a solid foundation. The anvil must be free to move in a vertical direction. Each of the twelve springs has an outside diameter of 8 inches, and consists of five coils of a rod $1-\frac{3}{16}$ inch diameter and seven coils of a rod $\frac{1}{2}$ inch diameter. The free height of the spring is $1-\frac{1}{8}$ inch, and height under a load of 6650 pounds, 7 inches. This axle-testing machine is in general use in America for testing axles, and is recommended by the Master Car Builders' Association of the United States. The specification for axles gives full details of

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a check on the analysis of the small test ingot may be made from drillings from the tensile specimen from each plate as rolled; and for other material, from drillings from one tensile specimen from each melt.

In the case of steel rails, splice bars, and the structural steel for buildings, bridges, and ships, it is proper to limit the analyses to drillings from the test ingot taken when pouring the heat, for a representative average sample of each melt or blow cannot in these cases be taken in any other way. No one who has studied the unavoidable variations in chemical composition of the different parts of a section of a rail—for instance, the bottom of the flange, the top of the head, and the centre of the head—will claim that the analysis of drillings from a rail is representative of the heat from which the rail was rolled. Furthermore, even with a proper percentage of discard, there is a variation in chemical composition between the rail from the top and from the bottom of the same ingot. These same statements are true of splice bars and of the structural steels.

Even with the test ingot it is necessary to exercise care to avoid segregation and obtain a representative average sample. Whenever the steel shows a decided tendency to rise in the small test ingot moulds, it is advisable to quiet it by adding a very minute quantity of pure metallic aluminium, for otherwise drillings taken for carbon determination in the vicinity of the blowholes will give misleading results. It is also advisable to roll or hammer the test ingot into a bar, and drill a hole through the bar, rather than to obtain the drillings for analysis from the test ingot itself. With these precautions the test ingot may be relied on to furnish a representative average sample of the melt or blow of steel.

27. *Methods for Chemical Analysis.*—All suggestions as to methods for chemical analysis have been purposely omitted from the specifications under discussion. Entire uniformity in the details of the various analytical methods used in steelworks laboratories will probably never be realised, nor is it a necessity in obtaining accurate chemical analyses.*

* The reader is referred to the excellent paper by the Baron Hanns Jüptner von Jonstorff entitled "The Introduction of Standard Methods of Analysis." *Journal of the Iron and Steel Institute*, No. I., 1896, pp. 80-138.

Figure 1. The effect of the concentration of the *Agrobacterium* suspension on the transformation efficiency of *Agrobacterium* strains. The *Agrobacterium* strains were grown in the YEA medium for 24 h at 28°C. The cell concentration of the strains was adjusted to 1.0 × 10⁸ cells/ml. The cell suspension was mixed with the plant tissue and the transformation efficiency was determined. The results were expressed as the mean ± SD of three independent experiments. The asterisks indicate the significant difference between the strains at the same concentration of the cell suspension.

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| Age Group | 1997 | 2000 | 2003 |
|-----------|------|------|------|
| 18-29 | ~85 | ~88 | ~92 |
| 30-49 | ~75 | ~78 | ~82 |
| 50-69 | ~65 | ~68 | ~72 |
| 70+ | ~55 | ~58 | ~62 |

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| Age Group | 2006 | 2007 | 2008 |
|-----------|------|------|------|
| 18-29 | ~85 | ~85 | ~85 |
| 30-49 | ~75 | ~75 | ~75 |
| 50-69 | ~65 | ~65 | ~65 |
| 70+ | ~55 | ~55 | ~55 |

for the reputable manufacturer. A review under this heading of the nine steel specifications shows that, in all cases but castings and forgings, every finished piece must be marked, except that small pieces may be shipped in bundles securely wired together, with the melt or blow number on a metal tag attached. In the case of rails, besides stamping the blow number of each rail, the name of maker, the month and year of manufacture, must be rolled in raised letters on the side of the web of each rail. In splice bars the name of maker and the year of manufacture must be rolled in raised letters on each side of the splice bar. In axles, besides the melt number the initials of the maker must be stamped on each axle; and in tires the maker's brand and number must be stamped on each finished tire.

I. INSPECTION.

31. Each specification makes ample provision to insure the inspector all facilities necessary for a thorough inspection of the material.

making it more brittle, and consequently wearing more rapidly. In regard to testing material, they found in a large number of places where material was used that they had alternate transverse strains. The axle, for example, was subjected to alternate transverse strains every time that it revolved. They were finding out that certain kinds of steel did not stand these strains. Some years ago they began to use axles as in the English practice, containing twenty to twenty-five hundredths of carbon. In a short time the journals began to drop off from those axles, and the matter became serious. When it came to them after it dropped off, there was an irregular portion of fresh break, the rest, being old, having broken off in detail from time to time. Many of these sections were more one-sided than others, but all had the detailed fracture. As a leap in the dark, they simply increased the tensile strength by 20,000 lbs. They were using 60,000 lbs. steel, and they jumped to 80,000 lbs., and their difficulty disappeared. The conditions under which the metal did its work must decide how they tested. He recognised the value of tensile test, elongation, and the contraction of area; but they had still to go further, and such papers as Mr. Colby's, showing what had been done and what could be done, were steps in the advancement of their knowledge.

Mr. R. A. HADFIELD, Member of Council, was much indebted to Mr. Colby for his paper. He wished to refer to that part dealt with by the author regarding the chemical properties which were to be specified in the steel according to standards decided upon. There were nine standard specifications under discussion, and where tensile strength was specified, limits in carbon had been purposely omitted except in the case of splice bars. Limits in manganese were included for tyres, boiler-plate, rivet steel, splice bars, and rails; and silicon only in case of tires and rails. The author had explained, however, that "phosphorus is very properly specified in all the different classes included in the nine steel specifications, and sulphur in all but rail steel and structural steel for building." Mr. Hadfield did not agree with these views. He was of opinion that chemical analyses should be a matter for the steelmaker, and should not enter into the engineer's specification. It was for the latter to

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| Age Group | 2003 | 2004 | 2005 | 2006 | 2007 |
|-----------|------|------|------|------|------|
| 18-29 | 78 | 75 | 78 | 75 | 95 |
| 30-49 | 72 | 70 | 72 | 70 | 90 |
| 50-69 | 65 | 62 | 65 | 62 | 85 |
| 70+ | 58 | 55 | 58 | 55 | 78 |

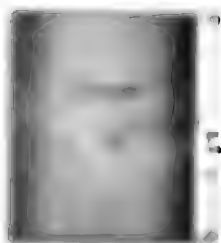
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The PRESIDENT said the Commission on steel rails, on which Mr. Martin and himself both sat, had issued their Report, and the St. Neots rail, which was the basis of the inquiry, contained local patches of martensite; but the Commission had not been able to explain satisfactorily the presence of this particular form of carburised iron. All the other points had been fully borne out by Mr. Colby's observations. What he (the President) thought was important in the case of steel rails was to know what had been their previous thermal treatment, the exact temperature at which the rolling had been performed—in fact, to know their life-history before they became rails. The St. Neots rail was an admirable one as regarded analysis. It might almost have formed a typical basis for specifications, and yet it was broken like glass into eighteen pieces, and not after a prolonged use; and then there was the presence of martensite. There were, he should not omit to say, the results of beautiful experiments in the Swedish Section of the Exhibition, by Mr. Brinell, and he strongly recommended the members to see them because they were of very great interest.

Mr. COLBY, in reply, said that there was one point made in the discussion to which he would like to reply. He referred to Mr. Hadfield's criticism that all chemical requirements should be omitted from specifications, and the manufacturer left free to select his steel, meeting the physical requirements specified. This same position was taken by French and German engineers who had participated in the long discussion of his (Mr. Colby's) paper on this subject, read at the International Congress on Testing Materials of Construction, held in Paris last July, and which discussion Mr. Greiner had just recommended the members of the Institute to read. Personally, he (Mr. Colby) was of the same opinion as Mr. Hadfield, for in his own experience, as Metallurgical Engineer of the Bethlehem Steel Company, he had often seen unnecessary hardships placed on the manufacturer by the strict adherence to definite limits in sulphur and phosphorus, and the rejection of steel because, perhaps, it contained 0.005 per cent. more sulphur than the limit specified. He would like to explain that these proposed American standard specifications were the result of a compromise, as they represented

study he was undecided as to which steel was the best, for although the soft rails wore faster in the beginning, say after 30,000 trains' passage, the hard rails were worn as much as the soft ones after 90,000 trains' passage. So he left it an open question. As for breakages, very few statistics were given from America, except that the rails break mostly at a cold temperature. Russia had a very large number of fractures. Sweden can be proud of its results in this respect, being in about the same position as England notwithstanding its severe climate. But the rails have always been kept on the soft side, or say about 0.42 per cent. carbon, with a maximum of phosphorus of 0.075 per cent. However, the Swedish Railway Administration had in 1898 been tempted by the American papers to increase the carbon up to 0.50 per cent., but found their rail fractures increased during last winter, so they have returned to their former hardness of 0.42 per cent., preferring to keep on the safe side; and at the same time they have increased their falling test by 10 per cent., since they found that rails breaking on the road during winter would stand in summer the specified test of a 1-ton ball falling 20 feet. As a proof of good wearing results from rails of a medium hardness, it may be mentioned that the Goliath rail, with a carbon of 0.43 per cent., laid down at Barrow ten years ago, under very heavy traffic, has only worn 3 mm., and is still wearing well. But rails have another function, namely, to withstand crushing, particularly at the ends, and in this respect there is no doubt that the hard steel would be preferable. As the President referred to Mr. Brinell's mode of testing in the Swedish Exhibition, he (Mr. Sandberg) might here mention that he used a similar mode in 1894, with a view to applying the same to rail inspection. See table of results herewith obtained from the crushing tests of sample steel of different hardness—0.40, 0.50, and 0.60 per cent. carbon, from three different makers. As shown by this table, the 0.60 per cent. carbon steel would stand twice as much load as 0.40 per cent. carbon did for the same compression, but this must not lead us to employ harder rails than will stand the traffic without breaking. The flattening of the rail ends is certainly a very costly matter, and often makes it necessary to renew rails before they are worn out, but this can to a great



THE INFLUENCE OF ALUMINIUM ON THE CARBON IN CAST IRON.

BY GODFREY MELLAND, B.Sc. (VICT.), ASSOC.R.S.M., AND HARRY W.
WALDRON, BOWEN SCHOLAR IN METALLURGY AT THE MASON
UNIVERSITY COLLEGE, BIRMINGHAM.

THE action of aluminium in causing the separation of graphite when added to cast iron containing carbide has been studied by W. J. Keep* in America, and more recently in this country by T. W. Hogg.†

Keep, looking at the question from the point of view of the practical foundryman, studied mainly the changes in the mechanical properties of white or hard grey irons, which are produced by the addition of definite amounts of aluminium to them when in the molten condition. In a later paper‡ he gives analyses of the treated metals. He found that a white iron became distinctly grey after the addition of 0.75 per cent. of aluminium, but that the amount of graphite separated and the softening of the metal increased up to 4 per cent. of that metal. He also noted that cast iron containing aluminium remained graphitic when cast in a chill mould.

In making a comparison between the action of silicon and aluminium upon the carbon in cast iron, he states that the metal when added in large amounts has the property, also possessed by silicon, of causing a reduction in the total carbon of the iron.

This last statement is not confirmed by the experiments of T. W. Hogg, which show that the total carbon remained practi-

* *Journal of the Franklin Institute*, vol. cxxvi, pp. 220-221.

† *Journal of the Iron and Steel Institute*, 1894, No. 11, p. 104.

‡ *Transactions of the American Institute of Mining Engineers*, vol. xviii, p. 142.

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| | Original Pig. | Remelted. | |
|--------------------------------------|---------------|----------------|-----------------|
| | | Slowly Cooled. | Rapidly Cooled. |
| Total carbon | 3.9 | 3.98 | 3.98 |
| Graphite | 0.38 | 0.76 | 0.48 |
| Combined carbon (by diff.) | 3.52 | 3.22 | 3.50 |
| Silicon | 0.24 | 0.28 | 0.28 |
| Manganese | 0.09 | 0.087 | 0.089 |
| Sulphur | 0.032 | 0.032 | 0.033 |
| Phosphorus | 0.066 | 0.065 | 0.065 |

The aluminium used was the best commercial metal made by the British Aluminium Company, and contained only about 1 per cent. of impurity, which consisted mainly of iron.

The meltings were made in fireclay crucibles heavily brasqued with powdered charcoal to prevent any possible increase in the amount of silicon from contact of the metal with the pot, and also to prevent excessive oxidation. The above analyses of the original metal show that it suffered practically no alteration in composition by the remelting.

The amount of metal used for each melting was between 3 and 4 lbs.

In the first few meltings the aluminium was placed at the bottom of the crucible, covered with a little powdered charcoal, and the pig iron was placed on the top. The whole was then melted down in the wind furnace, well stirred with an iron rod, and then poured. The subsequent analyses of these specimens showed that they contained in most cases the merest trace of aluminium. Investigation of the crucibles showed that the greater part of the aluminium was still adhering to the brasquing at the bottom, and had not passed into the iron at all, the thin layer of charcoal with which they were covered being sufficient to keep the two metals out of intimate contact with each other.

In the later experiments the aluminium was melted separately in a crucible, either alone or under coverings of flint spar or charcoal, and the molten iron was poured into it, the whole being well stirred as before. The best results were obtained when no charcoal or flint was employed in the melting.

Loss of Aluminium.—In making the alloys containing small amounts of aluminium, the quantities of this metal found in the

TABLE I.

| No. | Aluminium. | Silicon. | Total Carbon. | Graphite. | | Relative Density at 20° C. |
|-----|-----------------------|----------|---------------|-----------------|----------------|----------------------------|
| | | | | Rapidly Cooled. | Slowly Cooled. | Slowly Cooled. |
| 1 | Original pig. (None.) | 0.24 | 3.90 | 0.38 | 0.38 | ... |
| 2 | Pig remelted. (None.) | 0.28 | 3.98 | 0.48 | 0.76 | 7.64 |
| 3 | trace | 0.27 | 3.96 | 0.52 | 0.78 | ... |
| 4 | trace (0.002) | 0.25 | 3.94 | 0.43 | 1.06 | ... |
| 5 | 0.003 | 0.22 | 3.98 | 0.36 | 1.2 | ... |
| 6 | 0.023 | 0.23 | ... | 0.55 | 2.32 | ... |
| 7 | 0.024 | 0.23 | 3.93 | 0.30 | 1.20 | 7.58 |
| 8 | 0.026 | 0.27 | 4.07 | 0.50 | 1.87 | ... |
| 9 | 0.058 | 0.28 | ... | 0.50 | 1.73 | ... |
| 10 | 0.114 | 0.22 | ... | 0.54 | 2.64 | ... |
| 11 | 0.160 | 0.21 | 4.00 | 0.32 | 3.01 | ... |
| 12 | 0.179 | 0.22 | ... | 0.41 | 2.50 | ... |
| 13 | 0.180 | 0.20 | 3.90 | 0.57 | 1.55 | ... |
| 14 | 0.185 | 0.20 | ... | 0.55 | 2.8 | ... |
| 15 | 0.232 | 0.22 | 3.91 | 0.59 | 3.15 | ... |
| 16 | 0.250 | 0.19 | 3.96 | 0.91 | 3.49 | ... |
| 17 | 0.325 | 0.19 | ... | 0.92 | 2.91 | ... |
| 18 | 0.389 | 0.20 | ... | 1.51 | 2.96 | ... |
| 19 | 0.438 | 0.25 | 3.95 | 1.36 | 3.35 | ... |
| 20 | 0.527 | 0.21 | 3.83 | 3.06 | 2.93 | 7.12 |
| 21 | 0.566 | 0.21 | ... | 2.91 | 3.37 | 7.11 |
| 22 | 0.722 | 0.21 | 3.96 | 2.64 | 2.92 | ... |
| 23 | 1.239 | 0.21 | 4.08 | 2.95 | 2.97 | ... |
| 24 | 1.246 | 0.23 | ... | 2.81 | 2.87 | ... |
| 25 | 1.25 | 0.29 | ... | 2.91 | 3.01 | ... |
| 26 | 1.78 | 0.28 | 4.07 | 2.96 | 2.93 | 7.11 |
| 27 | 2.375 | 0.19 | 3.76 | 2.73 | 2.60 | ... |
| 28 | 3.82 | 0.22 | 3.59 | 2.53 | 2.54 | ... |
| 29 | 4.24 | ... | 3.57 | 2.28 | 2.49 | 6.88 |
| 30 | 8.31 | ... | 3.32 | 0.66 | 0.99 | 6.53 |
| 31 | 11.80 | 0.26 | 3.12 | 0.20 | 0.20 | 6.69 |

Remarks on the Analyses.—The analyses have in every case been carefully checked, and in doubtful specimens as many as three concordant results have been obtained. The method used for the estimation of the aluminium was the one described by J. E. Stead* in the *Journal of the Society of Chemical Industry*, vol. viii. p. 965, slightly modified to suit our requirements.

* Briefly, the method consists in adding to the solution of the mixed chlorides of the two metals a certain amount of sodium phosphate (varying with the amount of aluminium present), nearly neutralising and adding excess of sodium thiosulphate. This reduces most of the iron to the ferrous state and completely neutralises the hydrochloric acid, thus causing the precipitation of aluminium phosphate together with a small amount of ferric phosphate. This precipitate after filtering is redissolved and the iron completely precipitated by pure sodium hydrate. The aluminium is finally precipitated from the clear solution and weighed as the phosphate.

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Figure 1.

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cent. of aluminium the metal contains even less graphite than the original pig iron.

In the case of the slowly cooled specimens the amount of graphite liberated is somewhat irregular where the added aluminium is low. Thus No. 6 contains much more graphite than it should, judging from the numbers immediately above and below it in the series, while in No. 13 the effect of 0.18 per cent. of aluminium is very small by comparison with that produced by 0.179 per cent. in No. 12.

It must be pointed out that these anomalous cases all occur in metal containing less than 0.3 per cent. of aluminium, *i.e.* they are metals in which the aluminium effects no separation of graphite in the chilled specimens. Although the different meltings were made as nearly as possible under the same conditions, the temperatures at which the metals were poured no doubt varied very considerably in different cases, and this would lead to a good deal of variation in the rate of cooling. With a metal which is quite white when chilled it is obvious that comparatively slight differences in the rate of cooling would cause great variation in the amount of graphite separated. It would be impossible, without special heating and casting appliances, and a careful measurement of the temperature of the metal when poured, to obtain sufficient uniformity in respect to the rate of cooling to prevent these anomalies.

When the amount of aluminium exceeds 0.3 per cent., and its effect of accentuating the critical point for graphite separation begins to be more marked, we do not meet with any more of these irregularities. With the aluminium from 0.23 to 1.78 per cent. the slowly cooled specimens are uniformly grey, and all contain about 3 per cent. of graphite. With larger amounts of aluminium the graphite diminishes (but more slowly than in the rapidly cooled metal), until with 11.8 per cent. there remains only 0.2 per cent. of graphite, and the rate of cooling has absolutely no effect.

The curves (Plate XIV.) show the effect of aluminium up to 0.6 per cent. upon the separation of graphite in both slowly and quickly cooled specimens. Considerations of space have prevented us from carrying them forward up to 12 per cent. of aluminium. It may, however, be said, that two curves run close together

[illegible]

The rapidly cooled specimens, even when entirely grey, differ considerably in appearance from the corresponding slowly cooled specimens on account of the extreme fineness of their grain.

A few of the slowly cooled specimens in which the aluminium was low show a zone of grey metal extending about $\frac{1}{4}$ of an inch from the surface, the rest of the casting being either mottled or grey. Such specimens have been described before by J. W. Keep and R. A. Hadfield.* It seems not unlikely that this superficial grey-ness has arisen from the fact that those portions of the metal near the surface of the mould, under certain conditions as regards the temperature of pouring, would remain for a longer time within the critical range of temperature for graphite separation than the inner part, that part of the metal which first comes in contact with the mould, even when this is hot, and composed of a material which conducts heat badly, would immediately have its temperature very much reduced, and might pass through the critical range for carbon separation. Very soon, however, owing to the high temperature of the metal in the middle of the mould and to the bad conductivity of the mould, its temperature would rise and might pass again through the critical range. After a time it would, in the general cooling of the whole mass, pass through this range a third time. Under these conditions we might reasonably expect to find a greater separation of graphite near the surface of a small casting of metal, in which the tendency for this separation is not very decided, than in the central portion, where the critical temperature has been passed only once in the general cooling of the mass.

One of us having found that aluminium takes up carbon readily, forming the golden yellow carbide Al_4C_3 , at temperatures lower than that at which white cast iron melts, it occurred to us as not unlikely that the reduction of graphite in the specimens with 8 to 12 per cent. of aluminium might be due to the formation of this carbide. It was found, however, that there was no evolution of hydrocarbons when the finely powdered metal was treated with water, even on heating. An examination of a polished and etched specimen of the metal containing 11.8 per cent. of aluminium, moreover, did not lead to the discovery of any of the characteristic states of this compound.

* See *Journal of the Iron and Steel Institute*, 1894, No. II. p. 118.

1. The first step in the process of creating a new product is to identify a market need. This involves conducting market research to understand what consumers want and what problems they are facing. Once a need is identified, the next step is to develop a concept that addresses this need. This is often done through brainstorming sessions with a team of designers and engineers. The concept is then refined through prototyping and testing, ensuring that it meets the requirements of the market. Finally, the product is manufactured and distributed to the target audience. Throughout this process, it is important to maintain communication with the market and be prepared to make adjustments as needed.

2. The second step in the process is to develop a business plan. This document outlines the financial aspects of the product, including the costs of production, distribution, and marketing. It also includes a sales forecast and a break-even analysis. The business plan is used to secure funding from investors or lenders and to guide the company's financial decisions. It is important to have a realistic business plan that takes into account all the costs and risks involved in the product's development and distribution.

3. The third step in the process is to create a marketing strategy. This involves identifying the target market and developing a plan to reach them. This may include advertising, public relations, and direct marketing. The marketing strategy should be tailored to the product and the market, and it should be flexible enough to allow for adjustments as the company learns more about its audience. The goal of the marketing strategy is to create awareness of the product and generate sales.

4. The fourth step in the process is to launch the product. This involves getting the product into the hands of the target audience. This may involve setting up a distribution network, creating a website, and launching a social media campaign. The launch is a critical moment for the product, and it is important to have a plan in place to ensure that the product is well-received by the market. This may include offering promotions or discounts to encourage initial sales.

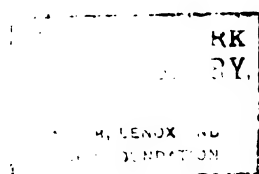
5. The fifth and final step in the process is to evaluate the product's performance. This involves tracking sales, customer feedback, and other key metrics to determine how well the product is performing in the market. This information is used to make adjustments to the product, the business plan, and the marketing strategy as needed. The goal is to ensure that the product is successful and profitable in the long run.

In conclusion we wish to express our indebtedness to Prof. Burstall for putting the testing machine of the Mason University College at our disposal for the purpose of these tests, and to Mr. F. Hummel for making the tests. Our thanks are also due to Mr. W. Macfarlane of the Wednesbury Technical School, who was good enough to take micro-photographs of some of our specimens.

periments with an alloy. Many years ago at Dowlais he made the earliest experiments ever attempted to estimate the amount of occluded oxygen in the steel. He estimated the amount of active oxygen by the effect it produced upon manganese introduced into the steel, and since then those results had been verified several times. He thought it was a point of very great consequence that the younger experimenters should pay more attention to this question of oxygen in steel. It was a very difficult point to study, but he was convinced that it was a point of very great importance, and it affected any experiments like those where they were examining what was the action of aluminium in throwing out the carbon in the form of graphite. He should like very much to see greater attention paid to the question of occluded oxygen and other gases in steel. It was a point which had been latterly lost sight of. Mr. Windsor Richards did a good deal in the examination of occluded hydrogen and carbon oxide. But the oxygen that was occluded in steel was of very serious consequence in many directions, especially in producing unsound steel in the form of blowholes. Dr. Dudley had raised the question, and it occurred to him that it was so intimately connected with the paper under discussion that, when called upon by the President, he thought it worth while to allude to it.

Mr. R. A. HADFIELD, Member of Council, said they were very much indebted to the authors of the interesting paper, but he should like to ask why they had selected as a base cast iron containing as much as 0.38 per cent. of graphite? There should be no difficulty in getting a pure carbide of iron, that is, in which graphite is practically absent. He had himself some of this material, and if the authors desired to continue their experiments, such material as they might require was with pleasure at their disposal. Referring to the amount of compression produced by varying loads, he noticed these only gave the total amount of reduction in length by compressions of 77 tons. He should like to know how much permanent deformation was produced by lowering loads 10, 20, and 50 tons. Another important addition to this paper would be to state the melting-point of the different mixtures by the pyrometers. There were







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The first of these is the fact that the system is not a simple one. It is a complex system, and the behavior of the system is not predictable. The second is that the system is not a simple one. It is a complex system, and the behavior of the system is not predictable. The third is that the system is not a simple one. It is a complex system, and the behavior of the system is not predictable.

Mr. MELLAND, in reply, thanked the members for the numerous hints as to the continuation of this research. If he had taken up all the points which they suggested to him, the work, such as it was, would have occupied four or five years at least. With regard to the cooling curves, that was an important part of the work, but he did not think of it till half the analyses were made; and as the analysis took up a great deal of time, he thought it would perhaps be better to deal separately with it. With regard to what Dr. Dudley said about the loss of aluminium, he could not account for that by the presence of any amount of oxygen in the cast iron. In the case of steel where they had practically no carbon present, they could easily conceive a good deal of oxygen there as oxide of metal or carbon monoxide, but in this cast iron he did not think they could have it. Still they had a very large percentage of loss of aluminium where the amount added was small. He was very pleased with what Mr. Hadfield had said about the separation of the graphite from the ferro-manganese or spiegeleisen. That suggested a use for aluminium. It was generally said that it might be interesting from a theoretical point of view; but that the metal was so expensive that it could not possibly be used. A small amount, however, would effect a very great softening of the metal, and it might be of practical value at once.

The PRESIDENT said Mr. Melland was one of his own pupils, and the joint authors deserved a hearty vote of thanks.

The following paper was then read:—

At the present time there are at least three types of mill in general use, viz., pull-over or two-high, non-reversing mills with fly-wheels, three-high mills with fly-wheels, and two-high reversing mills. Each of these is used for rolling all sorts of shapes and sizes, but in all of them the above-mentioned defects occur, and it is intended in this paper to suggest some means for counteracting them.

In rolling iron and steel as considered below, all the preceding and subsequent metallurgical processes will be neglected, and attention will be mainly confined to two points—the consumption of power and the waste of fuel and material. Much ingenuity has been expended in all industries in efforts to obtain economy in these directions, but it must always be remembered that over-refinement may have an effect the reverse of that which is intended. The size and weight of the raw material for the production of a given section of iron or steel is limited unconditionally as regards rolling-mills now in use, and there does not appear to be much prospect of great improvement in this direction for the present, although altered conditions often produce unexpected results. A very different state of things is seen, however, when consideration is given to the possibility of altering the ratio between the total amount of power used in driving and the proportion which is absolutely used in reducing the cross section of the work. In other words, it may be possible to greatly increase the efficiency of the rolling-mill.

The great defect of the present system of rolling-mill plant lies in the enormous masses that have to be set in motion to no effect. At any moment, the only part of the mill which does useful work is the particular groove through which the metal is passing. All the power consumed in driving the rest of the mill is so much wasted energy. This includes all the power expended in the idle rolls, the couplings, the gearing, and in the fly-wheel used in two and three high rolls.

Indicator diagrams were taken from the cylinder of an engine driving a two-high mill provided with a fly-wheel and rolling girders 220 millimetres deep. Running unloaded at 60 revolutions per minute, the horse-power developed was 81·3, which served to keep the engine, rolls, gearing, and fly-wheel in steady motion. Calculated from the frictional pressures, &c., the amount was

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that more or less of the total number of revolutions are wasted as far as useful work is concerned. During the operation of rolling rails on a three-high mill, for instance, some time is lost in raising the ingot after it has passed the first groove so that it may enter the second pass, and further time is taken in shifting it laterally to the third pass, and so on. All this time the rolls and the fly-wheel are being driven with the expenditure of steam. It is true that the steam consumption is less, but a little calculation shows somewhat surprising results as regards the waste of power during these idle intervals. In order to appreciate the losses in their right measure the different types of mills must be considered separately.

Two-high mills with fly-wheels are used at several works for rolling angle, tee, and other sections of small and medium sizes. New mills of this type are not built at the present time, but the existing plants are not being replaced. The number of loaded revolutions of such a mill is very small, and the same statement is true of the non-reversing plate-mill. In one case the total number of revolutions of the engine, when I-beams 280 millimetres deep were being made, was 6010, but of this number only 540 revolutions, or 9 per cent., did useful work as calculated by the total length of the material rolled. On another occasion the total number of revolutions was 5537 when making plate billets, and the useful number 404 or 7·3 per cent. On non-reversing mills producing plates 3 to 6 millimetres in thickness and 1 by 2 or 3 metres in area, the total number was 827 revolutions, of which only 47 or 5·7 per cent. did the necessary work.

Three-high mills with fly-wheels are in general use for producing the most different profiles of iron and steel. In smaller sizes as high speed trains they make common merchant iron, hoop iron, and wire rod; in larger sizes they produce beams, rails, and other large sections; as plate-mills their work is to manufacture sheets, boiler and ship plates, &c. The loaded run changes according to the shape and size of the rolled pieces and their longitudinal dimensions, and according to the nature of the appliances and machinery at hand. The method of making the observations being the same as before, three-high trains show 37 per cent. as their proportion of loaded run to the total runs under

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other dimensions of the pieces rolled and with other factors mentioned above. In certain cases they may be as high as 55 per cent. in the combined trains of two and three high sets or 60 to 70 per cent. in double two-high trains. However, as the ratio of loaded runs improves, the amount of dead weight driven also increases, as is characteristic of the light merchant trains.

Reversing-mills work, as a rule, without fly-wheels, though a fly-wheel has been used, as Mr. Ledebur states, but it did not come into general use. This type of mill may be used to produce any of the larger sections, such as rails, I-beams, constructional plates of great length, boiler and ship plates, &c., but their special use is for cogging ingots. The ratio of the loaded runs is closely dependent on the section, and on the efforts directed to economising the steam consumption. With short pieces the ratio will be reduced in consequence of the numerous revolutions made before and after the piece has entered and passed the rolls. With larger slabs the same result will be obtained for a similar reason. As the engine works near to the limit of its maximum power, the man in charge has to start early to obtain sufficient momentum to carry the work through. The number of unloaded revolutions, therefore, is increased at the start, and they are made with great steam consumption. A little slackness on the part of the men in stopping these large engines at the proper moment is also provocative of waste.

The ratio of loaded runs producing boiler plates is 37 per cent. ; constructional plates in longer lengths, 30 per cent. ; plate billets of lighter size and section, 25 to 30 per cent. ; girders of medium size up to 240 millimetres height, 50 per cent. ; axles for railway rolling stock up to 150 millimetres in diameter and 1300 kilogrammes in weight, 28 per cent.

These data have been gathered under the most favourable conditions for the trains to-day in use, in each case as regards steady work, careful and skilful workpeople, and experienced foremen, so that the calculations and statements given below may be regarded as well within the bounds of probability.

Given the consumption of fuel for producing steam for engines of different trains, the amount of wasted fuel can now approxi-

1. The first step in the process is to identify the problem or issue that needs to be addressed. This involves gathering information and understanding the context of the problem.

2. Once the problem is identified, the next step is to define the objectives and goals of the project. This helps to clarify what needs to be achieved and provides a clear direction for the team.

3. The third step is to develop a plan or strategy to address the problem. This involves breaking down the problem into smaller, manageable tasks and determining the resources needed to complete each task.

4. The fourth step is to implement the plan. This involves putting the strategy into action and monitoring progress to ensure that the project is on track.

5. The final step is to evaluate the results of the project. This involves assessing the outcomes against the objectives and goals and identifying any areas for improvement.

[illegible]

| Children in Household (X) | Children in Neighborhood (Y) |
|---------------------------|------------------------------|
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| 3 | 3 |
| 4 | 4 |
| 5 | 5 |
| 6 | 6 |
| 7 | 7 |
| 8 | 8 |
| 9 | 9 |
| 10 | 10 |

Of these products, the first two, 2730 + 270, or 3000 out of the 3630, represent the waste, and from this the proportion of the 800 kilogrammes in the first column may readily be calculated as 660 burnt to waste. The steam-producing capacity of coal is taken as uniform in spite of the variable amount of steam consumption in the unit of time. The length of steam-pipes, the large evaporating surfaces required in the boilers, the throttling of steam during the unloaded runs, &c., are amongst the defects that may be mentioned, but are to some extent counterbalanced by other circumstances. Under the most favourable conditions, therefore, the last two columns represent the minimum of waste, and the average will exceed it in most cases.

The number of times that the material has to be treated in separate mills must also be taken into consideration. In new iron and steel works intended for the production of large outputs of very varied sections, Bessemer or open-hearth steel is cast into ingots weighing from 2 to 3 tons; the ingots after cogging are cut into billets for rails or beams of two or three lengths, or for boiler plates and structural iron of standard sizes, and the rolling and finishing of the rails, beams, plates are carried out on second trains. In the manufacture of small sections or merchant iron, the billets require to be drawn down to smaller dimensions and lighter weights for their further manipulation, and this is done on a second train, and then the iron or steel is rolled to the intended section in a third mill. In some cases, as with hoop iron or wire rod, a fourth mill may be required to finish the operation.

The distribution of grooves into detached trains and the number of passes required for producing certain sections may vary widely. The greater the difference between the sectional dimensions of the ingot or billet and of the finished material, the more grooves has the material to pass through; and accordingly, in consequence of the defects of the steam-engine and rolling-mills, the larger is the waste of motive-power consumed by unloaded runs and revolving dead weights. Hence it will readily be granted that the quantity of fuel contained in the last two columns of the table above may be increased from 50 to 200 per cent. according to the size and shape of the output.

— THE JOURNAL OF THE AMERICAN MEDICAL ASSOCIATION —

Published by the American Medical Association, 535 North Dearborn Street, Chicago, Ill.

Subscription price, Five Dollars per Annum in Advance.

Single Copies, Fifteen Cents.

Entered as Second-Class Matter, May 2, 1882.

Postage paid at Chicago, Ill., and at additional mailing offices.

Acceptance for mailing at special rate of postage provided for in Act of October 3, 1917.

Postmaster: This publication is entered as second-class matter.

Postage paid at Chicago, Ill., and at additional mailing offices.

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Postage paid at Chicago, Ill., and at additional mailing offices.

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of rolls with accuracy very often necessitates much expenditure of labour, material, and time.

The conclusions deduced from these observations have led the author to seek for a solution of the problem under the given conditions, *i.e.* to construct a train in which the disadvantages enumerated above would be eliminated as completely as possible, and the problem does not appear to be difficult.

To avoid revolving dead weights, each groove is arranged in a separate pair of rolls. The dimensions of the rolls are settled by proportioning the material according to the power required. The elimination of unloaded revolutions is closely connected with the decrease of the weight, because fewer strokes of the engine are necessary to get up speed, and the smaller masses come to rest more speedily after the work is done. With the same object in view, it is desirable to use those forms of motors and driving-gears which require the shortest time possible for developing the maximum power. Under ordinary conditions the electromotor is preferable; but there are cases, however, where hydraulic engines or belt transmission may be advisable.

These ideas may be carried into practice in the manner represented in Plates XVI. and XVII., in which Fig. 1 is an end view and Fig. 2 a side view of a stand of rolls, each pair of rolls having a single pass only, while Fig. 3 is a suggested plan for a mill plant designed to roll girders 120 millimetres ($4\frac{1}{2}$ inches) in depth, from roughed slabs 150 by 180 millimetres (6 by 7 inches) in section, and weighing 370 kilogrammes (815 lbs.).

Each pair of rolls has a single pass only, and the rolls approximate to discs in form. They are made of steel to further reduce their weight, and their dimensions are proportioned to the work they have to do. The rolls are made with solid webs, or each roll may have a hollow or double web instead. In certain cases, as, for instance, in the preliminary reductions in a cogging mill, the rolls may be replaced by segments of a circle, to which a reciprocating motion will be given. The discs or segments are keyed on steel shafts *i*, running in bearings *a*, *b*, mounted on the bearers *c*, *d*. The bearings on the left-hand side are closed by end caps, while the shafts pass through the right-hand bearings to receive worm, belt, or other driving-gear. The bearers *c*, *d*, at the top and the bottom respectively, are rigidly connected to

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water-cooling. The omission of loose couplings, and the consequent reduction in breakages, need only be mentioned to be appreciated. Labour will be reduced, and will be directed into its proper channel as a controlling factor instead of being used in the form of brute force. The mill train will be capable of a very large output on economical lines, but at the same time it will feel to a much smaller extent any fluctuation in the demand from the iron markets.

The amount of work done on the ingots during the rolling and the coal consumed under the boilers will vary in proportion to the quantity of rolled iron delivered. For example, the twelve pairs of rolls required for producing girders of medium size can all work simultaneously in case of need when the market wants large quantities; but if the consumption falls off, the number of pairs of rolls working simultaneously will be reduced to suit the circumstances, and the coal consumption will be correspondingly lowered. On hoop iron or wire rod mills, automatic starting and stopping gear for the engine, operated by the work as it enters and leaves the rolls, would almost eliminate the need for work-people, who would then only be required to control the continuous co-operation between the heating furnaces and the mills.

The waste of material, time, and labour which the accurate setting of grooves entails will be nearly totally eliminated, and the changing and setting of a number of small rolls will be very much easier as compared with the huge masses that now have to be moved, while the saving in storage and in repairs will be very great. Duplicate sets of rolls and sets suitable for a very large number of sections could be kept, without waste of interest on idle capital. In conclusion, the author is strongly convinced that the results to be obtained in practice will far transcend those foreshadowed above, and that the installation of his system for rolling iron will effect great changes in the technology of iron as well as in its relation to common life.

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The author states that, by having only one groove in each pair of rolls instead of the required number of grooves in one pair of rolls, that it will economise material, time, and labour. In my opinion, it would be the reverse. Consider for a moment. To produce an ordinary sectional piece of steel (angles or rails), one requires at least four or five forming grooves, which means four or five pairs of rolls in the proposed mill. Suppose, when rolling angles, tees, or other similar sections, how can any one roll $\frac{3}{8}$ -inch and $\frac{1}{2}$ -inch thick in the same rolls if there is only one groove? It means changing rolls. Suppose it were possible to avoid changing rolls, could the author give any idea as to the time it would take to adjust the rolls, as there are eight nuts to loosen on each groove or pair of rolls, which means 32 to 40 nuts to be dealt with? This must take a considerable time, considering that the screws must be at least 4 or 5 inches in diameter to resist the strain which they will be subjected to. Whereas by having the five grooves in one pair of rolls, only six parts have to be dealt with in adjusting the rolls, and which can be done in two to three minutes, or even less.

Can the author give any idea as to the time it would take to change and fix up even five pair of rolls, and the number of men required to work the mill? because it appears to me that the greater the number of grooves worked the greater the number of men required.

The author also suggests that the tables conveying the piece from one groove to another shall be swinging ones. Will they not also have to be feeding ones, or what is to carry the piece into the rolls if the piece is at all heavy?

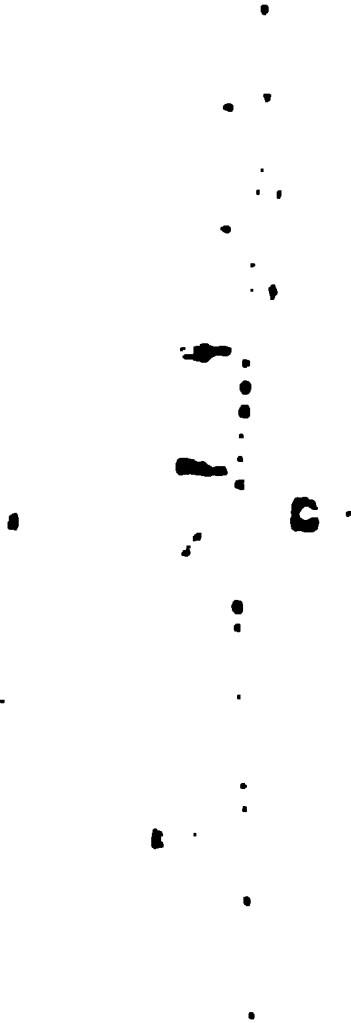
The author also suggests using steel rolls for lightness. My experience is that steel answers very well for cogging and roughing rolls, but is objectionable for finishing rolls, as the heat causes the steel to crack (surface cracks), after working a short time.

It is also suggested that the cogging rolls shall be discs or segments keyed on steel shafts. I am afraid it would not be a very substantial job. It answers very well for a short time as a patch. I have tried it with finishing rolls.

In my opinion it would be found a difficult matter to roll a number of sections of steel in proposed mill. It might do very well for girders, but a mill cannot be expected to be running







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VOTES OF THANKS.

The PRESIDENT : This meeting has been in every way a most charming one so far as it has gone, and I now propose "That the best thanks of the Iron and Steel Institute be hereby tendered to the chairman, Mr. Robert de Wendel, and to the members of the Local Reception Committee, for the great cordiality of the welcome extended to us, and for the arrangements, ably planned and successfully carried out, for the convenience, instruction, and pleasure of the members during the present meeting." That is the first part of a comprehensive motion. The second is : "That the best thanks of the members be also given to the President and Council of the Société d'Encouragement pour l'Industrie Nationale for their kindness in granting the use of their building for the purpose of the meeting." I need not dilate on the Société to any great extent, except that I would mention that this is the nearest analogue to our Society of Arts. It is over one hundred years old, and Dumas took the greatest interest and worked very hard for it, and is still an active member, and Mr. Carnot is now president. We have for a third time been received in this hall, and our warmest thanks are due to the Société d'Encouragement pour l'Industrie Nationale. The third part of the motion is : "That the best thanks of the members be given to the President, Council, and the Members of the Comité des Forges for their hospitable reception." When we remember how magnificently we were entertained last night, and the kindness of the Comité in providing music and an intellectual treat for us, we must feel that our gratitude will be not only very deep but very lasting. There are other thanks which I can hardly yet anticipate, except on the ground that gratitude is a lively sense of favours to come. We were received by Mr. Schneider at the Le Creusot Pavilion, and we are very grateful to Mr. Chapman, who has placed his office at our disposal, and also for the most excellent services of Mr. Vaslin. I hope that we shall have an opportunity in London of expressing the warmth of our feelings to Mr. Vaslin for his invaluable help. It is difficult here to do any one thing, but he has done very many things, and his efforts have been crowned

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THE CONSTITUTION OF SLAGS, AND THE PART
THEY PLAY IN THE METALLURGY OF IRON.

BY THE BARON JÜPTNER VON JONSTORFF (DONAWITZ, AUSTRIA).

THE various inter-reactions which take place between slag and metal represent one of the most important factors in most metallurgical processes. It may, therefore, not be out of place to consider from the modern point of view iron slags and some points of connection with the varying reactions which take place between them and iron.

Ledebur was the first to look upon slags as solutions, and not as complicated chemical compounds. He says on this point: * "All constituents of slags, and especially the before-mentioned oxides (metallic oxides and those of silicon, phosphorus, &c.), of which slags principally consist, occur together in quantities which vary extremely the one to the other, and are quite without relation to the laws of combination. Hence it follows that a slag need not consist of a single chemical compound, such, for instance, as a silicate of definite formula, but is to be viewed as a solidified solution in one another of different chemical compounds. It has been already pointed out that these compounds consist chiefly of the oxygen compounds of the metals and non-metals." Further,† he observes that "borax and microcosic salt serve in their molten condition as excellent solvents for all sorts of oxides, and they solidify with these to 'glasses' of homogeneous composition, no matter how great their relative weights are. If silica or phosphoric acid combine at high temperatures with lime, magnesia, ferrous oxide, or other substances, there is no reason to assume that we have not to deal in this case with a simple solution of the various substances in each other, but that absolutely definite chemical compounds have to be formed."

"That definite chemical compounds may form in a solution, and consequently also in a fluid slag, is, however, not to be doubted. Usually these compounds only become recognisable, it

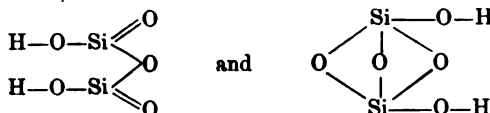
* *Handbuch der Eisenhüttenkunde*, 2nd ed., vol. i. p. 175.

† *Ibid.*, p. 176.

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Figure 1 is a line graph showing the percentage of total sample for each age group (0-14, 15-24, 25-34, 35-44, 45-54, 55-64, 65-74, 75+) across different years (1970, 1980, 1990, 2000, 2010, 2020). The y-axis ranges from 0 to 100. The x-axis shows the years. The 0-14 age group shows a steady decline from approximately 25% in 1970 to 10% in 2020. The 15-24 age group shows a slight increase from approximately 15% in 1970 to 20% in 2020. The 25-34 age group shows a slight increase from approximately 15% in 1970 to 20% in 2020. The 35-44 age group shows a slight increase from approximately 15% in 1970 to 20% in 2020. The 45-54 age group shows a slight increase from approximately 15% in 1970 to 20% in 2020. The 55-64 age group shows a slight increase from approximately 15% in 1970 to 20% in 2020. The 65-74 age group shows a slight increase from approximately 15% in 1970 to 20% in 2020. The 75+ age group shows a slight increase from approximately 15% in 1970 to 20% in 2020.



and similarly that some of these may only represent an aggregation of molecules of simpler silicic hydrates. This latter case *may* happen if the formula of a poly-silicic acid is the multiple of a simpler form, and it *must* happen if it represents a multiple of an ortho-silicic acid. In this way, too, silicates may be subdivided, and one obtains, for instance, meta monosilicates, ortho-disilicates, 6-basic-trisilicates, &c. In metallurgy another series of formulæ are usually employed, and this is shown in the following table together with the corresponding chemical formulæ:—

| | | | Molecular Formula for | |
|---------------------------------|--------------------------------|-------------------------------|--|--|
| Oxygen ratio.
Acid
Base = | Older Chemical
Description. | Metallurgical
Description. | Monoxide
Bases. | Sesqui-oxide
Bases. |
| 1 : 1½ . . . | One-third . . . | Sub-silicate . | " R ₂ SiO ₃ | " R ₂ SiO ₃ |
| 1 : 1 . . . | Semi . . . | Mono-silicate | " R ₂ SiO ₄ | " R ₄ Si ₂ O ₁₂ |
| 1½ : 1 . . . | Three-quarter . . . | Sesqui-silicate | " R ₄ Si ₂ O ₁₀ | " R ₆ Si ₃ O ₂₀ |
| 2 : 1 . . . | Mono . . . | Bi-silicate . | " RSiO ₃ | " R ₂ Si ₂ O ₉ |
| 3 : 1 . . . | ½ . . . | Tri-silicate . | " R ₂ Si ₂ O ₈ | " R ₄ Si ₂ O ₂₄ |

In order to obtain a more thorough knowledge of the constitution of silicate slags, use can be made of the melting-point curves and of the microscopic composition.

With regard to the latter, it may once for all be stated that amphibole minerals, felspar minerals, free acids, and free oxides have never been found in slags. The former, too, have never been produced by mineral synthesis (melting); alkali felspar cannot occur on account of the absence of adequate alkalis, and mellilite or gehlenite are always found in the place of anorthite and labradorite. Hence it follows that free sesqui-oxides and free silica are *ab initio* excluded as slag constituents in silicate slags.

As yet no melting-point curves for slags have been given, and indeed the statements as to the melting-points and temperatures of formation of slags are very scanty, as the following figures show:—

TABLE B.—*Alumina-Lime Mono-Silicates. Temperatures of Melting-Points determined by Seger Fusion Mixtures.**

| No. | Silica. | Alumina. | Lime. | Temperature of Formation of the Slag. |
|--------------|---------|----------|--------|---------------------------------------|
| | | | | ° C. |
| 1 | 1·8762 | ... | 3·4965 | 1570 |
| 2 | " | 0·1071 | 3·3217 | 1526 |
| 3 | " | 0·2141 | 3·1469 | 1492 |
| 4 | " | 0·3212 | 2·9720 | 1468 |
| 5 | " | 0·4283 | 2·7972 | 1451 |
| 6 | " | 0·5353 | 2·6224 | 1439 |
| 7 | " | 0·6424 | 2·4476 | 1430 |
| 8 | " | 0·7495 | 2·2727 | 1422 |
| 9 | " | 0·8565 | 2·0979 | 1417 |
| 10 | " | 0·9639 | 1·9231 | 1412 |
| 11 | " | 1·0707 | 1·7483 | 1410 |
| 12 | " | 1·1777 | 1·5734 | 1430 |
| 13 | " | 1·2848 | 1·3986 | 1468 |
| 14 | " | 1·3918 | 1·2238 | 1526 |
| 15 | " | 1·4989 | 1·0490 | 1613 |
| 16 | " | 1·6060 | 0·8741 | } above 1671 |
| 17 | " | 1·7130 | 0·6993 | |
| 18 | " | 1·8201 | 0·5245 | |
| 19 | " | 1·9272 | 0·3497 | |
| 20 | " | 2·0342 | 0·1748 | |
| 21 | " | 2·1413 | ... | |

TABLE C.—*Alumina-Lime-Magnesia Mono-Silicates. Temperatures determined by Seger Fusion Cones.†*

| No. | Silica. | Alumina. | Magnesia. | Lime. | Temperature of Formation of the Slag. |
|----------------|---------|----------|-----------|--------|---------------------------------------|
| | | | | | ° C. |
| 11 | 1·8762 | 1·0707 | ... | 1·7483 | 1410 |
| 22 | " | " | 0·1249 | 1·5734 | 1378 |
| 23 | " | " | 0·2497 | 1·3986 | 1365 |
| 24 | " | " | 0·3746 | 1·2238 | 1357 |
| 25 | " | " | 0·4994 | 1·0490 | 1352 |
| 25-A | " | " | 0·5410 | 0·9907 | 1351 |
| 25-B | " | " | 0·5826 | 0·9324 | 1350 |
| 26 | " | " | 0·6243 | 0·8741 | 1352 |
| 27 | " | " | 0·7491 | 0·6993 | 1359 |
| 28 | " | " | 0·8740 | 0·5245 | 1368 |
| 29 | " | " | 0·9988 | 0·3497 | 1381 |
| 30 | " | " | 1·1237 | 0·1748 | 1410 |
| 31 | " | " | 1·2485 | ... | 1497 |

Paul Gredt calculates as follows all the other mono-silicates containing alumina, magnesia, and lime, as, for instance, the slag consisting of $1·8762 \text{ SiO}_2 + 1·3918 \text{ Al}_2\text{O}_3 + 0·3496 \text{ MgO} + 0·7343$

* Paul Gredt, *Stahl und Eisen*, 1889, p. 756.

† *Ibid.*, p. 756.

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the specific and latent heats of slags vary with their composition, yet these differences are not so great as to prevent the curves for heat of fusion as given by Åkerman being at least similar to the curves for the melting-points.

Figs. 1 to 4 give the total heats of fusion of various silicates of lime or of lime and magnesia, from mono-silicates to the tri- or tetra-silicates. They resemble the well-known solidifying curves of solution. These curves give for each series of silicates two minima, &c.—

| | 1st Minimum. | 2nd Minimum. |
|--------------------------|--------------|---------------|
| CaO Silicate . . . | 1.5 Silicate | 2.83 Silicate |
| (3 CaO + MgO) Silicate . | 1.5 „ | 2.5 „ |
| (2 CaO + MgO) „ . | 1.5 „ | 2.39 „ |
| (CaO + MgO) „ . | 1.5 „ | 2.7 „ |

and three maxima, the middle one of which corresponds to—

| | |
|--------------------------------|---------------|
| In the CaO Silicate . . . | 1.87 Silicate |
| „ (3 CaO + MgO) Silicate . . . | 1.76 „ |
| „ (2 CaO + MgO) „ . . . | 1.78 „ |
| „ (CaO + MgO) „ . . . | 1.76 „ |

Similar curves are shown in Figs. 5 and 6 for FeO silicates and lime-iron silicates, borrowed from H. O. Hofman.*

In this way we recognise one of the solution constituents, a meta-silicate, while the minima to the right and left of this maximum must correspond to the solidification points of eutectic mixtures.

It could be foreseen that meta-silicates would occur in slags, as this silica hydrate is even known in the free state. Besides, Vogt † has shown that quite a number of meta-silicates occur in slags such as enstatite, MgSiO_3 ; hypersthene and bronzite $(\text{FeMg})\text{SiO}_3$; wollastonite, CaSiO_3 ; augite, $\text{Ca}(\text{MgFe})\text{SiO}_3$; rhodonite, MnSiO_3 ; babingtonite, $n(\text{MnR})\text{SiO}_3 + \text{Fe}_2\text{Si}_3\text{O}_9$; and a new hexagonal lime silicate, CaSiO_3 . Which, however, are the compounds that occur with these in the two eutectic mixtures? It cannot be free sesqui-oxide bases and free silica, since these, as we have seen, do not occur in slags. They must, therefore, be silicates. As the more basic compound, the ortho-silicate in the first

* "The Temperatures at which certain Ferrous and Calcic Silicates are formed in Fusion." *Transactions of the American Institution of Mining Engineers*, September 1899.

† "Studien over Slaggen;" *Bilhang till K. Svenska Vet. akad. Handlingar*, vol. ix. No. I.; "Om Slaggers af Sammansättningen beroende Kristallisations förhållanden," *Jernkontorets Annaler*, 1885; "Beiträge zur Kenntniss der Mineralbildung," *Kristiana*, 1892.

The last three members of the series are more or less hypothetical.

It now only remains to point out in what way the occurrence of the above-mentioned minerals is connected with the composition of the slags, in doing which the investigations of J. H. L. Vogt have chiefly to be considered. He says in this connection: "A comparative study of the analyses showed that the formation of minerals in the molten mass distinctly depends principally on the average chemical composition. The minerals result as products of the action, chemical affinity, and inter-reactions of the principal constituents—in other words, the formation of minerals depends upon chemical mass action. The different kinds of physical influence which are possible in the formation of slags exert only a small secondary influence on the formation of minerals if a certain minimum limit of time* for crystallisation is not exceeded."

In the highly siliceous enamel slags (2.5 silicates and those still more acid), Vogt states that globulites and crystallites of a silicate occur, which is possibly represented by the formula $(RO)_2(SiO_2)_3 - RO = CaO$ and MgO . From the bi-silicate slags enstatite crystallises out if the fused mass contains more MgO (+ FeO), as compared to CaO (+ MnO), than is shown by the molecular ratios 2.44 MgO : 1 CaO . On the other hand, augite crystallises out if more CaO is present than 1.40 MgO : 1 CaO . If the contents of lime exceed the limit 0.3 MgO : 1 CaO , wolastonite or the new hexagonal lime silicate crystallises out, the former probably from the fused masses richer in silica, and the latter from those poorer in silica. Rhodonite forms in bi-silicate masses if more MnO is present in proportion to RO (= CaO , MgO , FeO) than 1 MnO = 0.9 RO . On the other hand, augite separates when there is a lesser manganese ratio than 1 MnO : 7 RO . With an average MnO contents, when, for instance, there is 1 MnO : 1.82 RO , rhodonite and augite may form simultaneously.

In fused masses whose composition approximates to that of mono-silicates, olivine always forms if there is more RO (= MgO ,

* This is only a few minutes, at most five to seven, in the case of minerals free from alumina, as, for instance, the new tetragonal mineral, provided alumina is not present in the fused mass. For alumina minerals, on the other hand, in fused masses rich in alumina the time may be from several hours to several days.

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even if the slag contains silica, though it must not be more acid than a bi-silicate. In slags containing spinell, the separation of the magnetite takes place after the spinell, but before or simultaneously with the separation of the silicate minerals. Ferric oxide also readily enters into combination with other compounds. According to the investigations of L. Bourgeois, MnO can readily combine with Al_2O_3 and Mn_2O_3 .

An excess of Al_2O_3 disturbs the crystallisation process when the cooling is very rapid, though possibly not in the case of very basic masses. It consequently tends to render slags glassy. Sulphur always occurs in slags as monosulphide crystals of the cubic system, such as CaS , MnS , FeS , and isomorphic mixtures. In very basic enamel slags these compounds occur as globulites. In very basic slags sesquioxide compounds appear, therefore, to predominate, in addition to R.O bases.

By means of the diagram (Fig. 7, Plate XIX.) an approximate calculation of the composition of slags may be made. One calculates in the first place the ratio of the oxygen contents of the silica as well as of the total bases, with exception of Cu_2O which appears to have scarcely no affinity for silica. From the sum of the latter the half of the sulphur contents is deducted, corresponding to the oxygen equivalent of the RS, and then from this is calculated the ratio $\frac{\text{Acid oxygen}}{\text{Basic oxygen}}$. The composition of the slags can then be judged approximately, that is to say, the constituents present in the slags can be ascertained in this way. If the oxygen ratio exceed 2.0, the slags consist of the silicates RSiO_3 , and probably $\text{R}_2\text{Si}_3\text{O}_8$, or, written otherwise, RO.SiO_2 , and $(\text{RO})_2(\text{SiO}_2)_3$. The composition of the slags can then be expressed by the formula

$$x\text{RO.SiO}_2 + y(\text{RO})_2(\text{SiO}_2)_3$$

If s represents the oxygen contents of the silica and b that of the bases, then—

$$\begin{aligned} 2x + 6y &= s \\ x + 2y &= b, \end{aligned}$$

whence

$$y = \frac{s}{2} - b$$

and

$$x = 3b - s$$

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In slags with an oxygen ratio of less than one, and a high percentage of magnesia and alumina, and in bi-silicate slags with ferric oxide contents, there is another kind of calculation which shall be referred to later on. If the oxygen ratio lies between 1·0 and 0·5, and if for 1 CaO there is not more than 0·7 MgO + MnO + FeO, then one has—



and thence

$$2x + 2y = s$$

$$3x + 2y = b$$

whence

$$x = b - s$$

$$y = \frac{3}{2}s - b$$

EXAMPLE:—The slag contains—

| | Per Cent. | | Per Cent. |
|--------------------------------|-----------|-------------------|-------------|
| SiO ₂ | 28·32 | containing oxygen | = 15·10 = s |
| Al ₂ O ₃ | 24·24 | „ | = 11·30 |
| CaO | 40·12 | „ | = 11·46 |
| MgO | 2·79 | „ | = 1·12 |
| MnO | 0·07 | „ | = 0·02 |
| FeO | 0·27 | „ | = 0·06 |
| CaS | 3·38 | „ | = ... |
| } = 23·96 = b | | | |

$$\frac{\text{Acid oxygen}}{\text{Basic oxygen}} = \frac{15·10}{23·96} = 0·63$$

$$x = b - s = 23·96 - 15·10 = 8·86$$

$$y = \frac{3}{2}s - b = 22·65 - 23·96 = -1·31$$

We thus obtain for y a value which, though small, is a negative one and impossible, but which still shows that the slag consists chiefly of gehlenite, but must in addition contain some spinell. The quantity of this spinell ($\text{RO} \cdot \text{Al}_2\text{O}_3$) can be calculated in the following manner:—

The above slag can only consist of gehlenite and spinell. If the basic oxygen in gehlenite is called b_1 , then evidently $\frac{s}{b_1} = 0·67$, and from this the basic oxygen of the gehlenite can be calculated to be—

$$b_1 = \frac{s}{0·67} = \frac{15·10}{0·67} = 22·53$$

The oxygen contents of the spinell are consequently—

$$b - b_1 = 23·96 - 22·53 = 1·43$$

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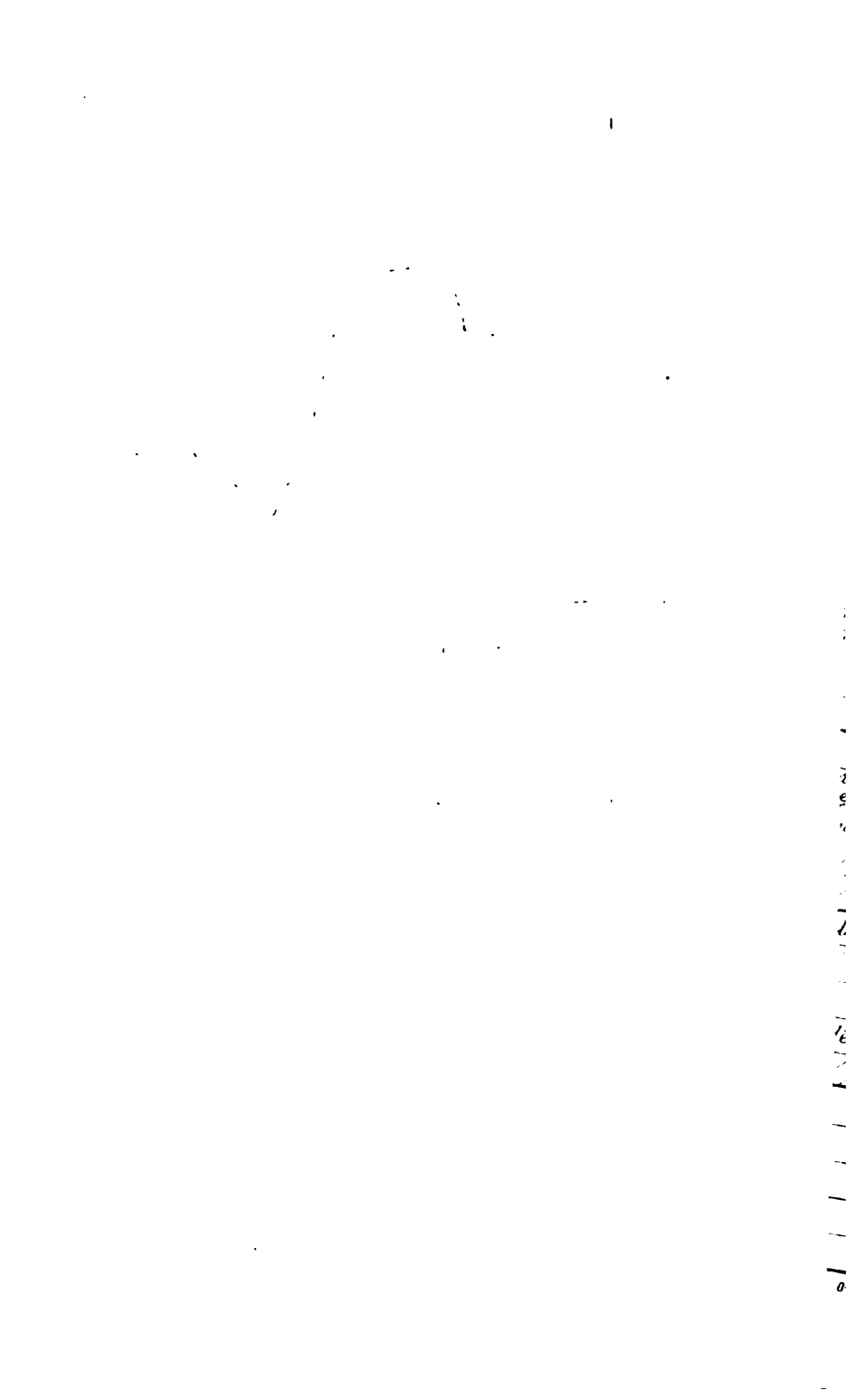
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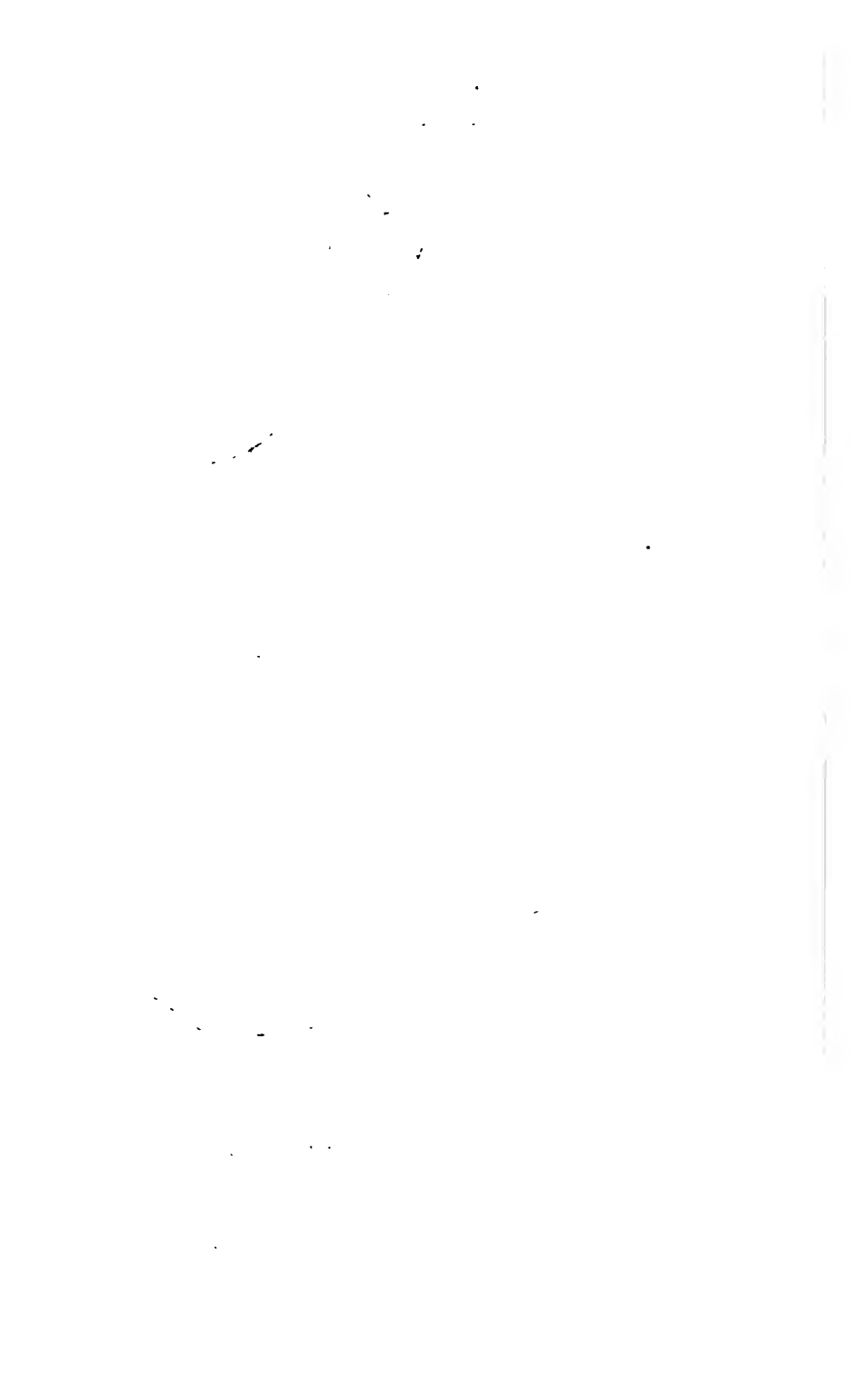
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at least approximately, if the oxygen ratio is less than that which corresponds to a mono-silicate. In a more acid slag, on the other hand, any spinell which may be present can only be determined by analytical methods. It must be particularly pointed out, however, that the calculation does not give only the $\text{RO} \cdot \text{Al}_2\text{O}_3$, but also $\text{RO} \cdot \text{Fe}_2\text{O}_3$ and $\text{RO} \cdot \text{Mn}_2\text{O}_3$. Spinell consists of RO (with 1 of oxygen) and Al_2O_3 (with 3 atoms of oxygen). The 1.09 molecule of spinell calculated above must therefore contain $3 \times 1.09 = 3.27$ molecules of Al_2O_3 , while as a fact only 2.30 Al_2O_3 are present. The slags can consequently contain only $\frac{2.30}{3} = 0.77$ of spinell, whilst the remaining oxygen of the base

namely, $17.37 - 13.00 - 4 \times 0.77 = 17.37 - 16.08 = 1.29$, must be in the form of free RO bases. The corrected composition of the slag is thus found to be $6.50 (\text{RO})_2 \text{SiO}_2 + 0.77 \text{RO} \cdot \text{Al}_2\text{O}_3 + 1.29 \text{RO}$.

From the paper by J. H. L. Vogt are taken the results of a series of investigations as to the spinell contents of a number of slags, which are now given to show how the results as to the percentage of spinell present obtained by calculation agree with the values which were found direct.

*Analyses of Blast-Furnace Slags by Muirhead.**

| Constituents. | | No. 128. | No. 129. | No. 130. | No. 131. | No. 132. | No. 133. |
|---------------|------------|----------|----------|----------|----------|----------|----------|
| | | Per Ct. | Per Ct. | Per Ct. | Per Ct. | Per Ct. | Per Ct. |
| Silica | | 24.32 | 28.74 | 27.01 | 26.46 | 27.53 | 27.64 |
| Alumina | | 23.47 | 25.63 | 20.13 | 23.44 | 22.23 | 22.93 |
| Lime | | 37.32 | 29.40 | 40.93 | 35.50 | 36.30 | 37.06 |
| Magnesia | | 13.23 | 13.75 | 11.09 | 13.34 | 13.00 | 12.95 |
| Totals | | 98.34 | 97.52 | 99.16 | 98.74† | 99.06 | 100.58 |
| Spinell | | 17.40 | 17.88 | 10.82 | 8.18 | 6.07 | 9.04 |
| Oxygen | { Silica | 13.12 | 15.16 | 14.41 | 14.11 | 14.69 | 14.75 |
| | { Alumina | 10.94 | 11.94 | 9.38 | 10.92 | 10.37 | 10.69 |
| | { Lime | 10.66 | 8.40 | 11.69 | 10.16 | 10.37 | 10.59 |
| | { Magnesia | 5.29 | 5.50 | 4.44 | 5.34 | 5.20 | 5.18 |
| Acid oxygen | | 0.49 | 0.59 | 0.56 | 0.54 | 0.57 | 0.56 |
| Basic oxygen | | | | | | | |
| MgO oxygen | | 0.49 | 0.65 | 0.37 | 0.52 | 0.50 | 0.49 |
| CaO oxygen | | | | | | | |

* Iron, October 15, 1880.

† 99.78 in original.

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The following table shows the composition of the slags as calculated by means of the formulæ already given:—

| | No. 128. | No. 129. | No. 130. | No. 131. | No. 132. | No. 133. |
|---|----------|----------|----------|----------|----------|----------|
| Gehlenite | 6.56 | 7.58 | 7.21 | 7.06 | 7.35 | 7.38 |
| Spinell | 1.83 | 0.80 | 1.00 | 1.32 | 1.00 | 1.11 |
| Oxygen in } Al_2O_3 . . . | 5.49 | 2.42 | 3.00 | 3.96 | 3.02 | 3.33 |
| spinell } RO | 1.83 | 0.80 | 1.00 | 1.32 | 1.00 | 1.11 |

If these numbers are compared with those that are obtained direct, it is found that—

(a) By calculation, a smaller percentage of $\text{RO Al}_2\text{O}_3$ is always found in the case of aluminates containing lime.

(β) When the aluminates are free from lime, calculation shows a larger percentage of $\text{RO Al}_2\text{O}_3$ than results from direct determination.

The latter might be explained by the partial decomposition of the $\text{MgO} \cdot \text{Al}_2\text{O}_3$, but the former is only explainable by inclusions in spinell.

For the approximate determination of the spinell, J. H. L. Vogt* has given the following empiric formula:—

$$\text{Spinell} = c(1 - a)\beta(\gamma - 4)(\gamma - 8)$$

in which a is the oxygen ratio $\frac{s}{b}$, Al_2O_3 being calculated as a base. β and γ are the percentage contents of MgO and Al_2O_3 , while c is a constant, and about equal to $\frac{1}{1160}$. This gives, however, somewhat inaccurate results, as even the figures given by Vogt show:—

| Calculated. | Found. | Calculated. | Found. |
|---------------|--------|---------------|--------|
| Ca 20 | 17.68 | Ca 13 | 6.07 |
| „ 17 | 17.40 | „ 3 | Ca 6.5 |
| „ 7 | 10.82 | „ 4.5 | „ 3 |
| „ 13 | 9.04 | „ 12 | „ 2 |
| „ 13 | 8.18 | „ 0.5 | „ 0.5 |

* See *Bihang till K. Svenska Vet. akad. Handlingar*, vol. ix. No. I. p. 161.

The following table gives a general view of the equations used in the slag calculations:—

| Mineral Composition of the g Constituents. | | $(RO)_2 \cdot (SiO_2)_3$ | $RO \cdot SiO_2$ | $(RO)_2 \cdot SiO_2$ | $(RO)_2 \cdot SiO_2$ | $RO \cdot R_2O_3$ |
|--|--|---------------------------------|--|---|---|--|
| | Oxygen Ratio in Mineral. | 3:1 | 2:1 | 1:1 | 2:3 | ... |
| | Minerals corresponding | Globulites in acid enamel slags | Hexagonal lime silicate, $CaSiO_3$
Wollastonite, $CaSiO_3$
Augite, $Ca(Mg)SiO_3$
Rhodonite, $MnSiO_3$
Babingtonite, $n(MnR)SiO_3 + Fe_2Si_2O_7$
Enstatite, $MgSiO_3$
Hypersthene, $Fe(Mg)SiO_3$
Bronzite, SiO_3 | Olivine, Mg_2SiO_4
Fayalite, Fe_2SiO_4
Tephroite, Mn_2SiO_4
Monticellite, $Ca_2SiO_4 + Mg_2SiO_4$
Willemite, Zn_2SiO_4
Mellilite, $(RO)_{12}(Al_2O_3)_2(SiO_2)_2$
New tetragonal mineral,* Akermanite ($R_4Si_2O_{10}$) | Gehlenite, $(RO)_2 \cdot Al_2O_3 \cdot (SiO_2)_2$ | Spinell, $RO \cdot Al_2O_3$
Magnetite, $RO \cdot Fe_2O_3$ &c. |
| 00 | ... | $\frac{s}{2} - b$ | $3b - s$ | ... | ... | ... |
| 00
0
30 | ... | ... | $s - b$ | $b - \frac{s}{2}$ | ... | ... |
| 00
0
57 | More CaO than CaO = $0.7(MgO + MnO + FeO)$ | ... | ... | $\frac{3}{2}s - b$ | $b - s$ | ... |
| 57 | Do. | ... | ... | ... | $\frac{s}{2}$ | $\frac{1}{4}(b - \frac{s}{0.67})$ |
| 00 | Less CaO than CaO = $0.7(Mg + MnO + FeO)$ | ... | ... | $\frac{s}{2}$ | ... | $\frac{1}{4}(b - s)$ |

There now only remains to be determined the limits between the minerals belonging to one and the same degree of silicification, a matter which may be of importance in many metallurgical

* Oxygen ratio=1.50. This mineral, whose degree of silicification occupies the mean between a bi-silicate and a mono-silicate, appears to take the place of a eutectic mixture. In calculating slag compositions no notice is taken of it.

processes. To obtain as good a general view as possible, we will place these on Vogt's data in the following table:—

| | Wolla-
stonite. | Hexagonal
Lime
Silicate. | Augite. | Rhodonite. | Enstatite
(Hypersthene) |
|---|--|--------------------------------|--|---------------------|---|
| Bi-silicates. | $(\text{MgO} + \text{MnO} + \text{FeO}) : \text{CaO}$
$(\text{CaO} + \text{MgO} + \text{FeO}) : \text{MnO}$
CaO
MgO
FeO
MnO | | 0.50 to 1.40
> 3.4 < 0.9 to 1.0 | | > 2.40
...
Little
} Paramount
... |
| | ... Paramount
Little
...
... | | ...
...
...
... | Little
Paramount | |
| | New Tetragonal
mineral free from
Al_2O_3
Åkermanite | | Mellilite | Gehlenite | Olivine |
| Mono-silicates and more basic
silicates. | $\text{CaO} : (\text{MgO} + \text{MnO} + \text{FeO})$
Al_2O_3 | | > 1.10 to $1.20 : 1$
3 per cent. to 5 per cent. | | < 1.10 to 1.20 |
| | $\text{CaO} : (\text{MgO} + \text{MnO} + \text{FeO})$
Al_2O_3 | | $> 1.1 : 1$
Higher than the above | | $< 1.1 : 1$ |
| | $\text{CaO} : (\text{MgO} + \text{MnO} + \text{FeO})$
Al_2O_3 | | Still somewhat higher than $1.20 : 1$
Less than 3 per cent. | | Somewhat less |
| | $a : b$ | | 1.30 to 1.50 | 1.30 to 0.80 | < 1.50 |

About and between the boundaries of two adjacent mineral areas both minerals can occur together.

G. Hilgenstock* assumes that in slags the silicate $\text{RO} \cdot \text{SiO}_2$ exists. He observes in this connection:—"Our blast-furnace slag, as we try to get it from the general average of the materials we have to deal with, we calculate in general from the formula $(\text{RO})_2 \cdot \text{SiO}_2$, and measure according to that the lime to be added, since we know that a silicate slag in which the sum of the oxygen of the bases is equal to the oxygen of the silica, taken on the whole, possesses an adequate degree of fusibility. That is to say, it is adequately fluid at a definite temperature, and it does not matter to us that such a slag contains considerable quantities of 'free lime' merely 'dissolved.' If, however, in consequence of a change in the materials at the same blast-furnace tempera-

* *Loc. cit.*

ture, and with an otherwise similar composition of the slag, the percentage power of solubility for free lime is exceeded, which becomes evident if the thick-fluid slag soon solidifies and decomposes, then if anything like an appearance of a want of lime is observable, the addition of lime is rapidly increased, and consequently also the percentage of 'free lime' in the slag, though it may be that we shall afterwards find that RO in the thick fluid decomposing slag was less than in that which at the same temperature was adequately fluid. I have only been able to explain various facts noticeable in the behaviour of molten blast-furnace slags by the solubility for free lime. The contents of free lime shows that in the case of our lime-basic blast-furnace slags there can be no question of a compound R_2SiO_4 , even though their constituents approximate to the formula $(RO)_2SiO_2$.

"In the case of a slag containing—

| | |
|----------------------------|-------|
| Silica | 34.18 |
| Ferrous oxide | 1.14 |
| Manganous oxide | 3.93 |
| Lime | 39.26 |
| Alumina | 16.73 |
| Magnesia | 2.32 |
| Calcium sulphide | 4.23 |

if as much of the lime as possible is extracted by means of a suitable sugar solution, one obtains for 39 SiO_2 , 37 CaO , whence it follows that the quantities approximate sufficiently accurately to the equivalents, and that the silicate of our lime-basic blast-furnace slags is the lime silicate $CaO.SiO_2$, and further, that it is of the type of carbonic acid, being derivable from the acid H_2SiO_3 ."

This view of Hilgenstock's is contrary to that derived from microscopic examination, and it therefore becomes necessary to examine whether his views are accurate or not. In the first place, the existence of the meta-silicic acid, as well as of the ortho-acid, is known with certainty, since there are not only numerous silicates corresponding to it, but the free acid itself is also known. It appears, therefore, to be at least very probable that the slags may contain ortho-silicate. On the other hand, the conclusion that in slags the silica can only be combined with lime appears very doubtful, as numerous distinctly defined double silicates are well known, and therefore the possibility of the

formation of other silicates can at least not be disputed. It may at once be admitted that the silica shows greater combining power for lime than for ferrous oxide, manganous oxide, alumina, &c., but in accordance with the laws of masses, it is certain that, in the presence of all these bases, silica must be combined not only with lime, but with all these bases (in accordance, on the one hand, with the relative degrees of affinity, and on the other with the mass ratios). The other bases can consequently certainly not be disregarded. If for the above-mentioned slag the oxygen ratio is calculated, one obtains—

| | Per Cent. | | Per Cent. |
|------------------------|-----------|---------------------|-----------|
| Silica . . . | 34.18 | containing oxygen = | 18.21 = s |
| Ferrous oxide . . . | 1.14 | " " | 0.25 |
| Manganous oxide . . . | 3.93 | " " | 0.87 |
| Lime . . . | 39.26 | " " | 11.22 |
| Alumina . . . | 16.73 | " " | 7.87 |
| Magnesia . . . | 2.32 | " " | 0.93 |
| Calcium sulphide . . . | 4.23 | " " | ... |

} = 21.14 = b

$$\frac{\text{Acid oxygen}}{\text{Basic oxygen}} = 0.86$$

According to Hilgenstock's view, the slag must contain a silicate of the composition—

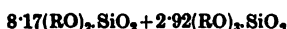
| | Per Cent. | | Per Cent. |
|------------------------|-----------|---------------------|-----------|
| SiO ₂ . . . | 34.18 | containing oxygen = | 18.21 |
| CaO . . . | 31.61 | " " | 9.11 |
| | 65.79 | | |

in which are dissolved—

| | Per Cent. | | Per Cent. |
|------------------------|-----------|---------------------|-----------|
| Free lime . . . | 7.65 | containing oxygen = | 2.11 |
| Ferrous oxide . . . | 1.14 | " " | 0.25 |
| Manganous oxide . . . | 3.93 | " " | 0.87 |
| Magnesia . . . | 2.32 | " " | 0.93 |
| Alumina . . . | 16.73 | " " | 7.87 |
| Calcium sulphide . . . | 4.23 | " " | ... |

} = 12.03

while according to the formula above stated the composition of the slag would be:—



the possibility of the formation of sesqui-oxides being left out of the question.

1. 2. 3. 4. 5. 6. 7. 8. 9. 10. 11. 12. 13. 14. 15. 16. 17. 18. 19. 20. 21. 22. 23. 24. 25. 26. 27. 28. 29. 30. 31. 32. 33. 34. 35. 36. 37. 38. 39. 40. 41. 42. 43. 44. 45. 46. 47. 48. 49. 50. 51. 52. 53. 54. 55. 56. 57. 58. 59. 60. 61. 62. 63. 64. 65. 66. 67. 68. 69. 70. 71. 72. 73. 74. 75. 76. 77. 78. 79. 80. 81. 82. 83. 84. 85. 86. 87. 88. 89. 90. 91. 92. 93. 94. 95. 96. 97. 98. 99. 100. 101. 102. 103. 104. 105. 106. 107. 108. 109. 110. 111. 112. 113. 114. 115. 116. 117. 118. 119. 120. 121. 122. 123. 124. 125. 126. 127. 128. 129. 130. 131. 132. 133. 134. 135. 136. 137. 138. 139. 140. 141. 142. 143. 144. 145. 146. 147. 148. 149. 150. 151. 152. 153. 154. 155. 156. 157. 158. 159. 160. 161. 162. 163. 164. 165. 166. 167. 168. 169. 170. 171. 172. 173. 174. 175. 176. 177. 178. 179. 180. 181. 182. 183. 184. 185. 186. 187. 188. 189. 190. 191. 192. 193. 194. 195. 196. 197. 198. 199. 200. 201. 202. 203. 204. 205. 206. 207. 208. 209. 210. 211. 212. 213. 214. 215. 216. 217. 218. 219. 220. 221. 222. 223. 224. 225. 226. 227. 228. 229. 230. 231. 232. 233. 234. 235. 236. 237. 238. 239. 240. 241. 242. 243. 244. 245. 246. 247. 248. 249. 250. 251. 252. 253. 254. 255. 256. 257. 258. 259. 260. 261. 262. 263. 264. 265. 266. 267. 268. 269. 270. 271. 272. 273. 274. 275. 276. 277. 278. 279. 280. 281. 282. 283. 284. 285. 286. 287. 288. 289. 290. 291. 292. 293. 294. 295. 296. 297. 298. 299. 300. 301. 302. 303. 304. 305. 306. 307. 308. 309. 310. 311. 312. 313. 314. 315. 316. 317. 318. 319. 320. 321. 322. 323. 324. 325. 326. 327. 328. 329. 330. 331. 332. 333. 334. 335. 336. 337. 338. 339. 340. 341. 342. 343. 344. 345. 346. 347. 348. 349. 350. 351. 352. 353. 354. 355. 356. 357. 358. 359. 360. 361. 362. 363. 364. 365. 366. 367. 368. 369. 370. 371. 372. 373. 374. 375. 376. 377. 378. 379. 380. 381. 382. 383. 384. 385. 386. 387. 388. 389. 390. 391. 392. 393. 394. 395. 396. 397. 398. 399. 400. 401. 402. 403. 404. 405. 406. 407. 408. 409. 410. 411. 412. 413. 414. 415. 416. 417. 418. 419. 420. 421. 422. 423. 424. 425. 426. 427. 428. 429. 430. 431. 432. 433. 434. 435. 436. 437. 438. 439. 440. 441. 442. 443. 444. 445. 446. 447. 448. 449. 450. 451. 452. 453. 454. 455. 456. 457. 458. 459. 460. 461. 462. 463. 464. 465. 466. 467. 468. 469. 470. 471. 472. 473. 474. 475. 476. 477. 478. 479. 480. 481. 482. 483. 484. 485. 486. 487. 488. 489. 490. 491. 492. 493. 494. 495. 496. 497. 498. 499. 500. 501. 502. 503. 504. 505. 506. 507. 508. 509. 510. 511. 512. 513. 514. 515. 516. 517. 518. 519. 520. 521. 522. 523. 524. 525. 526. 527. 528. 529. 530. 531. 532. 533. 534. 535. 536. 537. 538. 539. 540. 541. 542. 543. 544. 545. 546. 547. 548. 549. 550. 551. 552. 553. 554. 555. 556. 557. 558. 559. 560. 561. 562. 563. 564. 565. 566. 567. 568. 569. 570. 571. 572. 573. 574. 575. 576. 577. 578. 579. 580. 581. 582. 583. 584. 585. 586. 587. 588. 589. 590. 591. 592. 593. 594. 595. 596. 597. 598. 599. 600. 601. 602. 603. 604. 605. 606. 607. 608. 609. 610. 611. 612. 613. 614. 615. 616. 617. 618. 619. 620. 621. 622. 623. 624. 625. 626. 627. 628. 629. 630. 631. 632. 633. 634. 635. 636. 637. 638. 639. 640. 641. 642. 643. 644. 645. 646. 647. 648. 649. 650. 651. 652. 653. 654. 655. 656. 657. 658. 659. 660. 661. 662. 663. 664. 665. 666. 667. 668. 669. 670. 671. 672. 673. 674. 675. 676. 677. 678. 679. 680. 681. 682. 683. 684. 685. 686. 687. 688. 689. 690. 691. 692. 693. 694. 695. 696. 697. 698. 699. 700. 701. 702. 703. 704. 705. 706. 707. 708. 709. 710. 711. 712. 713. 714. 715. 716. 717. 718. 719. 720. 721. 722. 723. 724. 725. 726. 727. 728. 729. 730. 731. 732. 733. 734. 735. 736. 737. 738. 739. 740. 741. 742. 743. 744. 745. 746. 747. 748. 749. 750. 751. 752. 753. 754. 755. 756. 757. 758. 759. 760. 761. 762. 763. 764. 765. 766. 767. 768. 769. 770. 771. 772. 773. 774. 775. 776. 777. 778. 779. 780. 781. 782. 783. 784. 785. 786. 787. 788. 789. 790. 791. 792. 793. 794. 795. 796. 797. 798. 799. 800. 801. 802. 803. 804. 805. 806. 807. 808. 809. 810. 811. 812. 813. 814. 815. 816. 817. 818. 819. 820. 821. 822. 823. 824. 825. 826. 827. 828. 829. 830. 831. 832. 833. 834. 835. 836. 837. 838. 839. 840. 84

1. The first step in the process is to identify the problem or issue that needs to be addressed. This involves gathering information and understanding the context of the problem.

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1. The first step is to identify the problem or question that needs to be addressed. This involves understanding the context and the specific requirements of the task.

2. Next, it is essential to gather relevant information and data. This can be done through research, consultation with experts, or by analyzing existing resources.

3. Once the information is gathered, the next step is to analyze it. This involves identifying patterns, trends, and key factors that influence the outcome.

4. After analysis, a plan or strategy should be developed. This plan should outline the steps to be taken, the resources required, and the timeline for completion.

5. The final step is to implement the plan. This involves executing the tasks, monitoring progress, and making adjustments as needed to ensure the goal is achieved.

Throughout the process, communication and collaboration are crucial. Regular updates and feedback loops help to keep everyone on track and address any challenges that arise.

In conclusion, a systematic approach to problem-solving involves identifying the problem, gathering information, analyzing it, developing a plan, and implementing it. This process ensures that the solution is well-informed and effective.

| | Per Cent. |
|--------------------|-----------|
| P_2O_5 | 38.51 |
| CaO | 60.08 |
| SiO_2 | 0.10 |

They were all colourless, and contained less inclusions than those derived from basic slag, these latter constantly appearing opaque or coloured brown by metallic oxides.

In basic slags the phosphate occurs, it is true, in hexagonal prisms, but chiefly in the tabular form of the rhombic system, as well as in small bright blue crystals with a diamond-like lustre, which, according to Bücking* and Linck, are monoclinic. The order in which these separate out is the following:—

(1.) Rhombic tabular crystals. These separate out at the highest temperatures reached.

(2.) Hexagonal prisms (acicular crystals). These separate from the solution, now poorer in phosphoric acid, at a lower temperature.

(3.) Blue lustrous monoclinic crystals. These separate out still later than the above. With the latter crystals appear black fern-like acicular groupings of a substance which, according to Stead and Ridsdale,† consists of calcium ferrate and calcium aluminate.

This probably explains, too, how it was that in the crucible experiments, in which the temperature of the converter is far from being attainable, no rhombic tabular crystals were produced.

The crystals of the "tetra-basic" calcium phosphate show, without exception, considerable quantities of inclusions of foreign substances, as is shown by the following analyses:—

A.—Hexagonal Prisms.

| Constituents. | G. Hilgenstock. | Stead. | Bücking and Linck. |
|---------------|-----------------|-----------|--------------------|
| | Per Cent. | Per Cent. | Per Cent. |
| P_2O_5 | 34.94 | 33.707 | 36.77 |
| CaO | 57.35 | 53.536 | 53.51 |
| MgO | | 0.426 | 0.40 |
| Fe_2O_3 | | 4.557 | 1.78 |
| FeO | 4.10 | 1.226 | 2.22 |
| MnO | | 0.720 | ... |
| Al_2O_3 | | 1.343 | ... |
| SiO_2 | 3.24 | 3.243 | 3.61 |
| S | | 0.400 | trace |
| Cl | | | trace |
| Al_2O_3 | | | 1.09 |

* *Neub. u. Ann. Chem.* 1887, p. 243.

† *Loc. cit.*

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produced in the blowpipe flame exerts an influence as well as the ordinary action of the oxygen of the air on other constituents contained in the basic slag. Probably there is produced at the same time CaO.FeO or $\text{CaO.Fe}_2\text{O}_3$. FeS and $\text{MnO.Fe}_2\text{O}_3$ can also play a part in this change ($2\text{CaO} + 2\text{FeS} + \text{O} = 2\text{CaS} + \text{Fe}_2\text{O}_3$ or $2\text{CaO} + \text{MnO.Fe}_2\text{O}_3 + \text{O} = \text{CaO.Fe}_2\text{O}_3 + \text{CaO.MnO}_2$). It is not, however, only the CaO split off from the $\text{Ca}_4\text{P}_2\text{O}_7$, which passes into insoluble compounds, but also the free lime that was there from the very beginning.

Of the other constituents occurring in basic slag, mention shall be made in connection with the oxide slags. In the meantime it will be enough to point out that the calculation of the composition of basic slag is made by first calculating the tetra calcium phosphate from the percentage of phosphoric acid present, and then calculating the remainder as a silicate or oxide slag.

EXAMPLES.

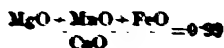
A.—Basic Open-Hearth Slag.

| | Per Cent. | | Per Cent. |
|-------------------------|-----------|---------------------|------------|
| SiO_2 | 13.90 | containing oxygen = | $4.17 = s$ |
| P_2O_5 | 2.30 | " " | 1.30 |
| Al_2O_3 | 2.80 | " " | 1.31 |
| FeO | 24.62 | " " | 5.47 |
| MnO | 10.41 | " " | 2.34 |
| CaO | 39.50 | " " | 11.27 |
| MgO | 5.76 | " " | 2.30 |

The 1.30 oxygen of the phosphoric acid corresponds to $1.30 \times 0.80 = 1.04$ oxygen in the lime (which gives $\frac{1.04}{4} = 0.26$ molecule of $\text{Ca}_4\text{P}_2\text{O}_7$). We have thus, after deduction of the oxygen in the calcium phosphate—

| | Per Cent. |
|---------------------------|-----------|
| Oxygen in SiO_2 | 7.41 = s |
| " Al_2O_3 | 1.31 |
| " FeO | 5.47 |
| " MnO | 2.34 |
| " CaO | 10.23 |
| " MgO | 2.30 |
| } 21.65 = b | |

$$\frac{s}{b} = 0.34$$



To the 0.213 of oxygen in phosphoric acid 0.16 lime-oxygen corresponds. There consequently remains—

| | Per Cent. |
|-------------------------------------|-------------|
| Oxygen in SiO_2 | 12.66 = s |
| „ Al_2O_3 | 0.63 |
| „ Fe_2O_3 | 0.77 |
| „ FeO | 3.16 |
| „ MnO | 6.46 |
| „ CaO | 3.05 |
| „ MgO | 6.76 |

 $b = 20.83$

$$\frac{s}{b} = 0.61$$

$$\frac{\text{MgO} + \text{MnO} + \text{FeO}}{\text{CaO}} = 5.37$$

The slag consequently consists of—

0.04 molecule calcium phosphate.

6.33 molecules olivine.

0.47 molecule spinell and magnetite.

5.29 molecules free RO bases.

D.—Basic Bessemer Slag.

| | Per Cent. | | Per Cent. |
|-----------------------------------|-----------|---------------------------|-----------|
| SiO_2 | 11.71 | containing oxygen = | 6.24 |
| P_2O_5 | 18.15 | „ „ | 10.23 |
| Al_2O_3 | 1.01 | „ „ | 0.47 |
| Fe_2O_3 | 2.78 | „ „ | 0.83 |
| FeO | 7.19 | „ „ | 1.60 |
| MnO | 4.05 | „ „ | 0.91 |
| CaO | 48.19 | „ „ | 13.77 |
| MgO | 6.38 | „ „ | 2.50 |
| S | 8.09 | corresponding to oxygen = | 0.05 |

8.15 lime-oxygen corresponds to the 10.23 P_2O_5 oxygen (2.05 $\text{Ca}_2\text{P}_2\text{O}_9$), and there consequently remains—

| | Per Cent. |
|-------------------------------------|--------------|
| Oxygen in SiO_2 | 6.24 = s . |
| „ Al_2O_3 | 0.47 |
| „ Fe_2O_3 | 0.83 |
| „ FeO | 1.60 |
| „ MnO | 0.86 |
| „ CaO | 5.59 |
| „ MgO | 2.50 |

 $11.85 = b$

$$\frac{s}{b} = 0.53$$

$$\frac{\text{MnO} + \text{MnO} + \text{FeO}}{\text{CaO}} = 0.89$$

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If the MnO is not adequate to combine with all the P_2O_5 , FeO probably takes a part.

While it has with certainty been shown that in phosphate slags only the calcium phosphate $Ca_4P_2O_6$ occurs, views vary as to the FeO and MnO phosphate present. Some believe that these are 3-basic,* and consequently correspond to the formula $Mn_3P_2O_8$ and $Fe_3P_2O_8$, while others here too consider that the tetra-basic phosphates† $Mn_4P_2O_9$ and $Fe_4P_2O_9$ occur.

Fortunately this affects the slag calculation but little. One finds in the first place the quantity of base oxygen corresponding to the P_2O_5 oxygen by multiplying the latter by the factor 0.6, while in the second case one must take the factor 0.8. The number of molecules of phosphate remains in this unchanged, and there is only a slightly increased quantity of residual basic oxygen for the silicate in the first instance. An example will make this clear, and for this we will select the first of the analyses of puddling-furnace slags given above:—

| | Per Cent. |
|-----------------------------|-----------|
| Oxygen in SiO_2 | 8.92 |
| „ Fe_2O_3 | 4.80 |
| „ FeO | 7.52 |
| „ MnO | 5.93 |
| „ CaO | 0.38 |
| „ MgO | 0.23 |
| „ P_2O_5 | 2.62 |

The 0.38 of lime-oxygen is corresponded to by 0.48 P_2O_5 oxygen. There consequently remains to combine with RO bases $2.62 - 0.48 = 2.14$ of P_2O_5 oxygen. If we in the first place assume that here too tetra- or octo-basic phosphates are formed, the 2.14 of P_2O_5 oxygen corresponds to 1.71 of RO oxygen, and there remains—

| | Per Cent. |
|-----------------------------|-----------|
| Oxygen in SiO_2 | 8.92 = s |
| „ Fe_2O_3 | 4.80 |
| „ FeO | 7.52 |
| „ MnO | 4.22 |
| „ MgO | 0.23 |

} 16.77 = b

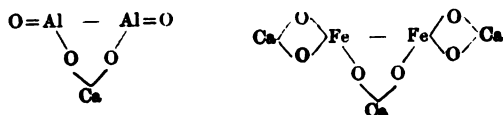
$$\frac{s}{b} = 0.53$$

* Or rather 6-basic.

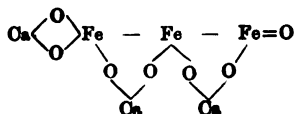
† Or more accurately 8-basic.

| Age Group | Education Level | Percentage (%) |
|-----------|-----------------|----------------|
| 18-29 | High School | ~45 |
| | Some College | ~50 |
| | Bachelor's | ~65 |
| | Master's/PhD | ~70 |
| 30-49 | High School | ~55 |
| | Some College | ~60 |
| | Bachelor's | ~75 |
| | Master's/PhD | ~80 |
| 50-69 | High School | ~65 |
| | Some College | ~70 |
| | Bachelor's | ~85 |
| | Master's/PhD | ~90 |
| 70+ | High School | ~65 |
| | Some College | ~70 |
| | Bachelor's | ~85 |
| | Master's/PhD | ~90 |

of $(RO)_3R_2O_3$, cannot be disputed, as can be represented by the following constitution formulæ:—



For the assumed compound $(CaO)_3Fe_2O_4$ the following formula would apply:—



It is, however, just as possible that, as a matter of fact, corresponding to spinell, only the compound $RO.R_2O_3$ exists, which, however, may crystallise with excess quantities of RO and R_2O_3 . To the latter assumption support is given by the occurrence in nature of the magnetic iron ores, &c., in which, as compared with the formula $RO.R_2O_3$, both monoxide bases and sesquioxide occur in excess.

To be able to form any definite judgment on this point detailed investigations are necessary, especially of the fusion curves of such slags. In the meantime it will suffice for practical purposes to consider these slags as mixtures (or solutions) of $RO.R_2O_3$ and RO (or respectively R_2O_3 .)

It need not be pointed out that in these slags, in addition to the above-named compounds, small quantities of phosphates, silicates, and sulphides may also occur.

A special class of oxide slags occurs in iron alloys under certain conditions in the form of inclusions. Their characteristic is the deficiency of sesqui-oxides (accidentally admixed alumina being disregarded). This is owing to the fact that they are at once reduced to monoxides by the excess of metal near them. These inclusions consist of mixtures of monoxides with silicates and mono-sulphides. Occasionally, however, the silicates are quite subordinate. The inclusions may, of course, also contain phosphates. Examples of the composition of such inclusions are afforded by the following analytical results:—



The following slag from soaking pits :—

| | Per Cent. | | Per Cent. |
|--|-----------|----------------------|-----------|
| SiO ₂ | 3·14 | containing of oxygen | 1·67 |
| P ₂ O ₅ | 0·068 | „ „ | 0·039 |
| Fe ₂ O ₄ | 24·77 | „ „ | 6·83 |
| FeO | 68·31 | „ „ | 15·18 |
| MnO | 1·047 | „ „ | 0·232 |
| CaO | 1·03 | „ „ | 0·294 |
| MgO | 0·83 | „ „ | 0·332 |
| S | 0·021 | „ „ | 0·0105 |
| Total | 99·216 | | |

The degree of silicification—

$$= \frac{1·67}{22·73} = 0·07$$

From this the mineralogical composition of the slag is calculated to be—

| | Molecules. |
|--|------------|
| Manganese sulphide | 0·011 |
| Calcium phosphate | 0·008 |
| Gehlenite (RO) ₃ (SiO ₂) ₂ | 0·84 |
| Magnetite | 1·71 |
| Free RO bases | 13·48 |

As an addendum, attention must be drawn here to the connection which exists between slags and fire-resisting materials. The former are relatively easily fusible solutions in one another of several substances, themselves only fusible with considerable difficulty. Fire-resisting materials can be considered as the more difficultly fusible members of the slag series. This purely theoretical relation between slags and refractory materials has, however, some importance in practice. Thus, the rule is derivable from this, that only such refractory materials should be used for furnace construction as are insoluble, or only very slightly so, in the slags that will be produced in any particular smelting process.

Published Weekly, Except on Sundays, Holidays, and Days of the Week when the Issue is Double

Vol. 48, No. 1, January 1, 1932

Published by the American Medical Association, 535 North Dearborn Street, Chicago, Ill.

Subscription Price: \$5.00 per Annum in Advance. Single Copies: 15 Cents.

Entered as Second-Class Matter, October 3, 1917. Postpaid at Special Rate of \$5.00 per Annum.

Acceptance for mailing at special rate of postage provided for in Act of October 3, 1917.

Postmaster: Please Send Address Changes to JOURNAL OF THE AMERICAN MEDICAL ASSOCIATION, 535 N. DEARBORN ST., CHICAGO, ILL.

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built up from water and a salt, or from two salts fused together, or from two silicates, or from two metals, or from iron and carbon. Therefore the point of view of the phase-doctrine embraces widely different problems.

I have, therefore, examined the problem of iron and steel from this point of view, making use of the most accurate numbers obtained by Sir W. Roberts-Austen in his recent studies. Fig. 2 (Plate XX.) represents the results of my study. It resembles in many respects Fig. 1, which is Roberts-Austen's. In fact, the new lines that are introduced principally result from the knowledge I had obtained as to the solidification and transformation of solid solutions, which enabled me to give a better correlation of the different parts of the figure.

Let us consider first the solidification of liquid solutions with 0-2 per cent. carbon. I have added the curve $A p r a$, which has been traced as a straight line, because its position is not exactly known. All these solutions with 0-2 per cent. of carbon solidify to homogeneous solid solutions, but the process takes place in the following manner.

Take a solution q , trace the horizontal line $q p$, then p represents the composition of the first crystals that separate from that solution. They *must* contain less carbon than the liquid. The liquid will be enriched in carbon, and its temperature of solidification is thereby lowered, and so the liquid passes successively from q to s . In the meanwhile the mixed crystals of iron and carbon change also with the fall of the temperature from p to r , and at last the whole solution becomes solidified into homogeneous mixed crystals of the composition r , that of the original liquid being q . The solidification, however, has not taken place at a constant temperature, but over the interval qr .

So it proceeds until the point a is reached, which indicates the presence of 2 per cent. of carbon. From 2-4.3 per cent. of carbon there is first a gradual solidification as before, until the remaining liquid has reached the point B , and the crystals have reached the point a , and then the remaining liquid solidifies at a constant temperature of 1130° according to Roberts-Austen, so as to form what I like to call a conglomerate of carbon and mixed crystals of the composition a , which may perhaps be 2 per cent. of carbon.

At 1130° there exists by contact with one another a liquid

1. The first part of the document discusses the importance of maintaining accurate records of all transactions and activities. It emphasizes that proper record-keeping is essential for transparency and accountability, particularly in financial matters.

2. The second part outlines the various methods and tools used to collect and analyze data. This includes the use of surveys, interviews, and statistical software to ensure that the information gathered is reliable and valid.

3. The third part focuses on the ethical considerations surrounding data collection and analysis. It highlights the need to protect individual privacy and ensure that data is used responsibly and for its intended purpose.

4. The fourth part discusses the challenges faced in the process of data collection and analysis, such as incomplete data, bias, and the complexity of interpreting results. It provides strategies to overcome these challenges and improve the quality of the research.

5. The fifth part concludes by summarizing the key findings and recommendations of the study. It stresses the importance of ongoing monitoring and evaluation to ensure that the data remains relevant and useful over time.

6. The final part of the document provides a detailed appendix of the data collected, including raw data tables and supplementary information. This section is intended to provide a comprehensive overview of the data used in the study.

7. The document also includes a list of references to the sources used in the research, ensuring that all information is properly cited and acknowledged.

8. Finally, the document includes a section for the author's contact information and a statement of the work's funding sources, providing transparency about the research's financial support.

We will now first trace the history of the mixed crystals which can exist beneath the curve *Aa*. I have changed nothing in the Roberts-Austen lines *GO*, *OS*, and *SE*, and the interpretation of the separation of β iron, α iron, or cementite is also accepted. That a solid solution may reject one of its components or a compound just as a liquid solution does when it is cooled, was an entirely unknown phenomenon a few years ago, but it has now been demonstrated in some cases which have been the object of researches by my pupils.

The existence of three allotropic states of the iron, the discovery of which we owe to Mr. Osmond, is not exceptional. The researches of later years have so multiplied our knowledge of the allotropic forms of solid bodies, that it is at present far more peculiar for a body not to present allotropy than to do so. As regards metals, there is the new case of tin, which presents a transition point at 20° C., just like the transition point of γ into β iron at 890° . The succession of three such states in iron is no longer to be wondered at, for ammonium nitrate shows four of them, and therefore the transformations of the martensite crystals with 0-0.86 per cent. of carbon only admits of a rational explanation if the existence of the three varieties of iron are admitted. The right understanding of these phenomena was, however, impeded by the fact that no analogous phenomena were known to occur at more convenient temperatures. I have, therefore, pointed out the complete analogy of the lines *GO* and *OS* with the lines that represent the successive separation of the different modifications of ammonium nitrate from its liquid solution, according to the amount of water present. The same phenomena are observed in the separation of solid TiNO_3 or AgNO_3 from their fused mixture.

My studies on mixed crystals led me, however, to consider also the possibility that the β and α iron also hold some carbon in solid solution, although less than the γ iron. This would give some complications in the figure *G O S P* which it is difficult to describe briefly. It would, however, greatly influence the results obtained in an attempt to deduce the molecular weight of the carbon in the solid solution from the observed lowering of the transition point.

As regards the iron-carbon alloys with more than 2 per cent.

AMERICAN MEDICAL ASSOCIATION
PUBLISHED WEEKLY

CHICAGO, ILL., MAY 1, 1914

Vol. 21, No. 19

Subscription price, \$5.00 per annum in advance

Single copies, 15 cents

Entered as second-class matter, May 2, 1882

Postpaid by mail at special rate of postage provided for

newspapers by act of Congress of October 3, 1917

Acceptance for mailing at special rate of postage provided for

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have led me to accept this line in preference to the lines EK and KL of Roberts-Austen and of Stansfield; nor can I sum up the considerations which I have adduced to explain the many anomalous results obtained with highly carburised iron. A prominent part is played by the retardations which are possible in all the processes of transformation which occur during cooling. There is also to be taken into account the influence which retardation has upon the production of cementite during the period of solidification, and during the two following periods above and below 1000° .

Again, the straight line PSK at 690° is also wholly in harmony with the known interpretation that it gives the transformation of the residual solid solutions of 0.85 per cent. of carbon (point S) into a conglomerate of α ferrite and cementite, which is known by the name of pearlite. To the right of S this same transformation is accomplished at the same temperature in martensite which is accompanied by cementite; to the left of S it is accomplished in martensite accompanied by α ferrite. Therefore 690° is analogous to a eutectic point.

As to the possibility of passing this point as well as the curves GO, OS, ES, in abrupt cooling, and thereby preserving to the ordinary temperature the γ state of the iron as mixed crystals or solid solutions, I have nothing to add to this way of explaining the process of hardening.

The different fields obtained in Fig. 2 give the limits of concentration and temperature for the most prominent of the phases that appear in the carbon-iron system. There are some others about which our knowledge is far too imperfect to make it possible to indicate their place. Only in the case of austenite has such an attempt been made, but the position austenite should occupy in the system still remains highly hypothetical.

The previous endeavours to determine the molecular weight of carbon in the solid solution may be re-examined in connection with the new line A α , and possible alterations in the figure GOM. The results of such an examination point to the fact that the carbon molecule probably only contains a single atom, but it cannot be decided whether the carbon is free or is present as Fe_3C .

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The Solidification of Carburised Iron.

This, as was stated in the first paper, is now generally admitted to be closely analogous to the freezing of a saline solution, the solids which separate being:—(1) Iron (in the γ state), containing a variable amount of carbon dissolved in it; (2) graphite; and (3) a eutectic or fusible mechanical mixture of 1 and 2.

The amount of carbon which is held in the state of solid solution in the iron depends upon the amount of carbon in the fluid solution from which it separated, and, until the saturation point is reached, it is probably roughly proportional to it. Professor Roozeboom has recognised this fact by the addition, in Fig. 2 of his paper, of the line Aa , which represents the proportion of dissolved carbon in the solid iron which separates at any temperature, and this line, and other analogous lines which will be found in his paper, enable the very complicated facts to be more readily interpreted.

The line Aa is drawn from A , the freezing-point of pure iron, to a point a on the eutectic line aBC ; the position of a denoting the maximum amount of carbon which solid iron can permanently hold at that temperature without separation of graphite. The exact position of a has not yet been determined, but it could probably be obtained experimentally by cooling a series of pure carburised irons very slowly from the molten condition to just below 1130° and then quickly to the ordinary temperature: the proportion of carbon for which graphite just began to separate, would indicate the true position of a .

In my last paper I placed a at 1.2 per cent. carbon, as this was the point at which the formation of graphite was evident in the cooling curves. A careful consideration of the progress of solidification as described by Professor Roozeboom in his summary, will bring to light the important fact that the process can only take place as he describes it *if the rate of cooling is very slow*. Thus in his Fig. 2, tracing the solidification of a liquid having the composition q , the solid which separates will have at first the composition p , but as the composition (and temperature) of the residual liquid changes from q to s , that of the deposited solid

100 000

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1. The first step in the process is to identify the problem or issue that needs to be addressed. This involves gathering information and understanding the context of the problem.

2. Once the problem is identified, the next step is to define the objectives and goals of the project. This helps to clarify what needs to be achieved and provides a clear direction for the team.

3. The third step is to develop a plan or strategy to address the problem. This involves breaking down the problem into smaller, manageable tasks and determining the resources needed to complete each task.

4. The fourth step is to implement the plan. This involves putting the strategy into action and monitoring progress to ensure that the project is on track.

5. The final step is to evaluate the results of the project. This involves assessing the outcomes against the objectives and goals and identifying any areas for improvement.

1. *Journal of the American Medical Association*, 277: 1005-1006, 1997.

1. *Chlorophyll a* and *Chlorophyll b* were determined by the method of Arar and Collins (1971). The concentration of chlorophylls was expressed as $\mu\text{g mL}^{-1}$ of the sample.

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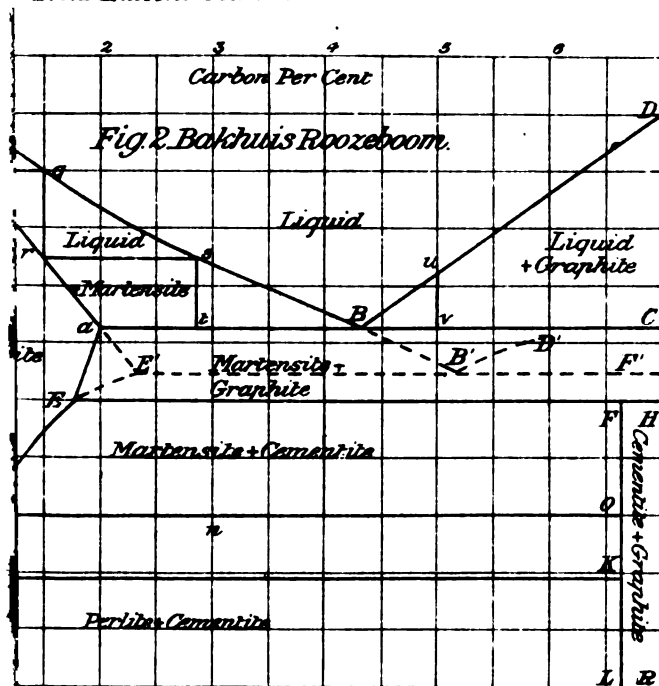
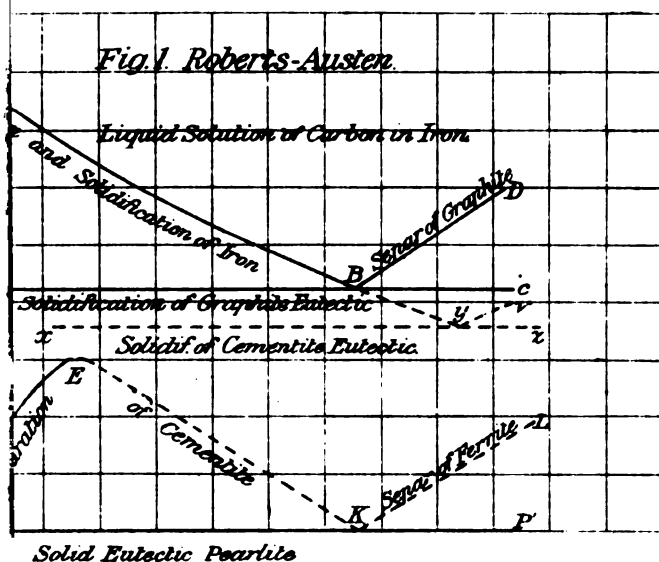
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1. **Introduction**

outside. The *average* composition of the crystal will be p and r , and there will, therefore, be some of the enrichment remaining, which may eventually form a eutectic. It is evident, therefore, from this that the process of solidification does not in general stop at the line Aa , but that the formation of a eutectic alloy, with subsequent separation of graphite, takes place in steels containing a smaller percentage of carbon than corresponds to the point a (which is about $1\frac{1}{2}$ per cent. carbon). In proportion as the rate of cooling is decreased, the diffusion of carbon in the solid steel crystals will make the composition more and more to the composition r , and when equilibrium has been established, it will coincide with r . When the whole liquid will consequently have solidified, a fact which is capable of easy arithmetical demonstration. In a true equilibrium curve, which Professor Roozeboom's Fig. 2 really is, the line Ba will stop where it meets the line Aa .

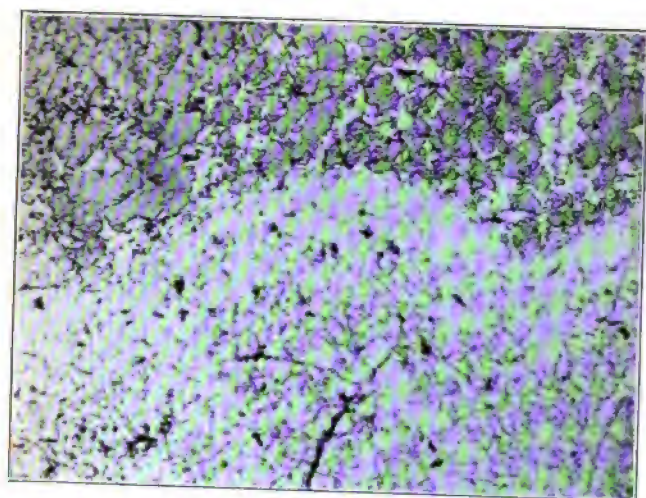
In view of the above, it is probable that the position of the line Aa is somewhat to the right of that given in my last paper, where it was 1.2 per cent. carbon. The position assigned to it by Professor Roozeboom (2 per cent.) is probably approximately correct. In my last paper I advanced the hypothesis, based on the slope of the line AB , that the carbon in fluid iron was monatomic, and that the iron which solidified contained about half as much carbon as the liquid from which it was formed. This would give a composition of 2.1 per cent. carbon, which is in general agreement with the 2 per cent. suggested by Professor Roozeboom. The monatomic condition of carbon in molten iron is, I think, supported by the observation of Ramsay that the metal alloys are monatomic, carbon here playing the part of a gas.

The following equation, which is a modification of that of Chatelier, enables the exact shape of the line Aa to be determined from that of the line AB , provided that the latent heat of fusion of pure iron be known. The assumption is also made that carbon is monatomic in the liquid metal. In a somewhat complicated form, which will be sufficiently accurate for the present purpose, the equation is $2\frac{dx}{x}(1-c) = \frac{\lambda}{T^2} dT$. In this x is the number of molecules of iron in 100 molecules



Figs. 1 and 2.

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K
AST. S. LENOX AND
TIGER FOUNDATION



Inner
Portion.

Outer
Portion.

FIG. 1.—Pure carburised iron annealed for two days. Portion near edge $\times 56$ D.

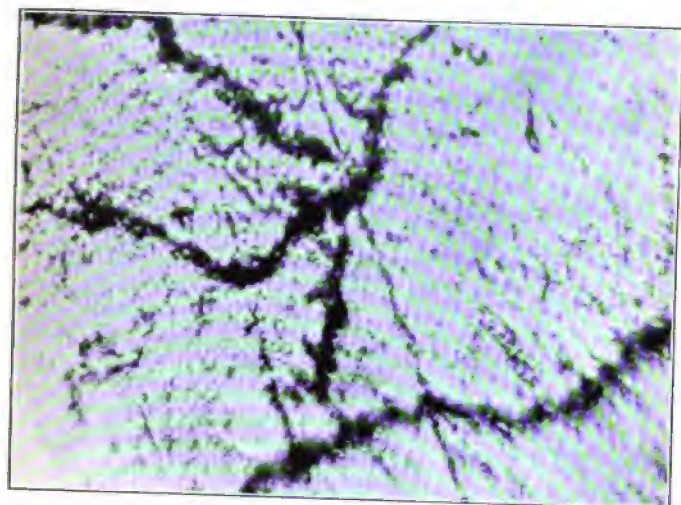


FIG. 2.—Lower portion of Fig. 1 $\times 1580$ D.



PLATE XXII.

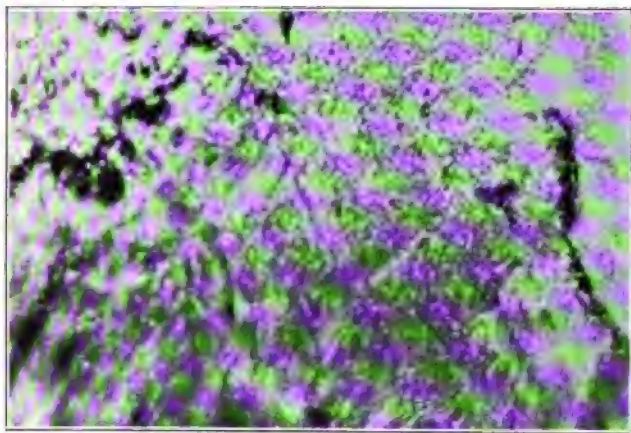


FIG. 3.—Upper portion of Fig. 1 $\times 1580$ D.

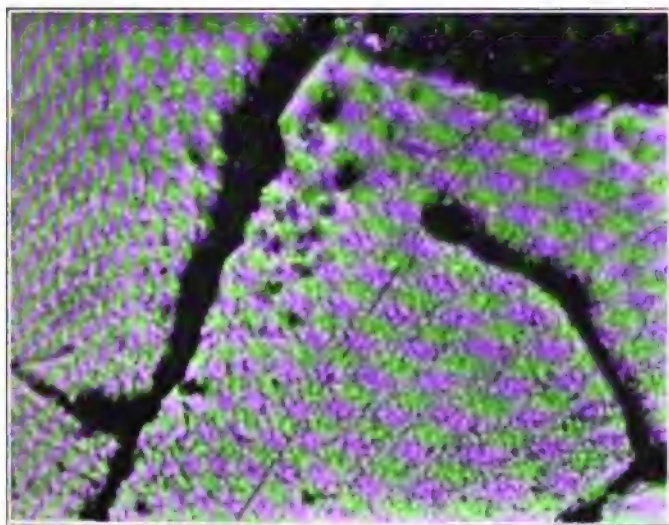
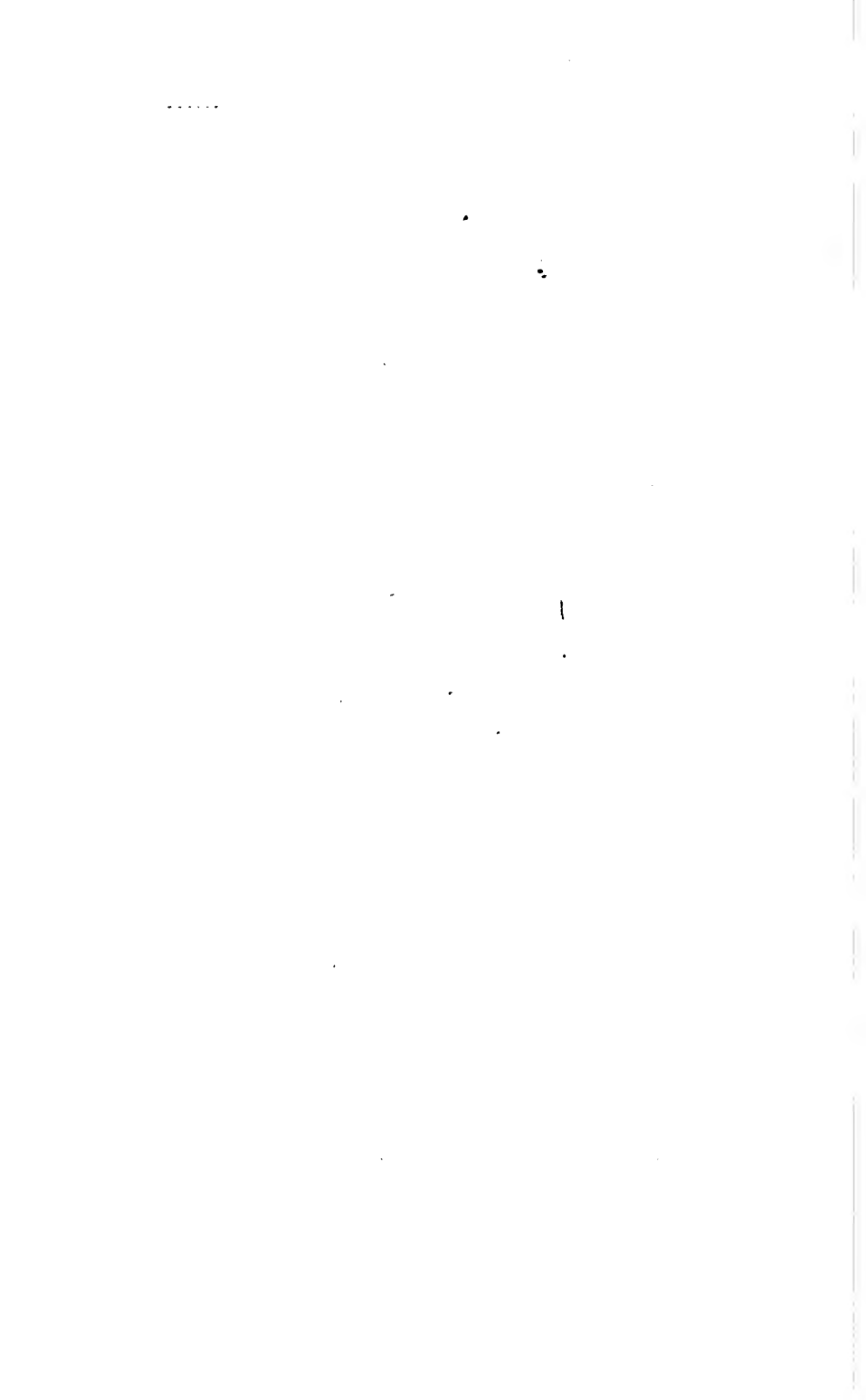


FIG. 4.—More highly carburised iron, containing when fluid 7 per cent. carbon and 3 per cent. silicon. Combined carbon 0.22 per cent. The section shows only ferrite and graphite.



and of carbon in the molten alloy. T is the temperature of solidification measured from the absolute zero (-273° C.), and c is the ratio between the percentage of carbon in the solid and in the liquid from which it was formed, the percentage being reckoned in molecules. λ is the latent heat of fusion of one gram molecule of iron. Taking Person's value of 20 calories per gram, it becomes 1120.*

The result of this calculation places a at about 2 per cent., but I have adopted 1.8 per cent. provisionally, as it appears to agree better with the evidence obtained from other sources. The general curvature of the line Aa is, however, obtained by means of the calculation; it will be observed that it has a somewhat stronger curvature than the line AB .

Turning now to the solidification of liquids to the right of B , the process is the same as has already been described, except that a eutectic alloy is finally left containing about 4.3 per cent. of carbon. This solidifies at points on the line aB forming a mechanical mixture of graphite and of a solid solution of carbon in iron having the composition a . I may incidentally observe that the true meaning of a eutectic alloy has already been fully described and need not be dealt with here.

Passing to the right of B , an excess of carbon is found above the amount required to make the eutectic, which contains 4.3 per cent. of carbon. This excess of carbon crystallises out as graphite at points on the line BD . Professor Roozeboom asks whether this graphite is pure carbon, or whether it too is a solid solution of iron in carbon. In order to test this I intend to determine the amount of iron in a quantity of "kish" which separated from a rich sample of carburised iron during slow cooling from the molten state. The kish had previously been boiled with dilute hydrochloric acid to extract any iron that might be mechanically entangled.

There will still, however, be some uncertainty whether the iron was really dissolved or only mechanically mixed with the graphite. The question is not of great importance, but if a series of determinations of the amount of iron in graphite were found to give concordant results it would appear to be in favour of Professor Roozeboom's suggestion.

* Roberts-Austen and Stansfield, *Bull. Phys. Congress*, Paris, 1900. 1900.—ii.

With regard to the slope of the line BD, it must be remembered that this part of the curve is somewhat difficult to obtain by the ordinary method of taking cooling curves, as the heat evolved by the separation of graphite is very slight, and the extrusion of graphite from the cooling mass renders the carbon percentage of the original fluid metal somewhat uncertain. If the line BD is prolonged up to the point which would represent pure carbon, it will be found to reach a temperature of at least 8000°C . We do not know at what temperature graphite melts, as Moissan has shown that it volatilises without any sign of fusion at the highest temperature of the arc, say about 3000°C ., but its melting-point can scarcely be so high as 8000°C . This is, however, not at all anomalous, as it is in agreement with the fact that the ideal curve is not in general a straight line, but has one or two points of curvature which would probably reduce the melting-point of graphite to a more reasonable temperature.

Professor Roozeboom's question whether there is any change in the character of the separated solid as we proceed up the line BD, must, I think, be answered substantially in the negative, as the tendency would be for the solid to become more and more nearly pure carbon, and it is practically pure to begin with; we know, moreover, of no decided change in the physical nature of graphite until it reaches the temperature of the arc, at which it rapidly vapourises.

Changes after Solidification.

In the lower part of the equilibrium curve, relating to solidified cast iron, it will be seen that important alterations have been made since my previous paper. The difficulty in obtaining these curves, by the usual method of taking cooling curves, has arisen from the extreme slowness with which the changes occur in the solid metal, and it may be well to give a short account of the different stages by which our present knowledge of the subject has been gained. When the diagram was first published, in 1897,* the curve SE, which shows the solubility of cementite in pig iron, was left incomplete at E, as the positions of points beyond this were uncertain. The solution theory appeared to

* Roberts-Austen, Fourth Report to Alloys Research Committee. *Proc. Inst. Mech. Eng.*, 1897.

prolonged annealing on carbonised iron, which in the main agree with those of Dr. Percy, will be described a little later, as they appear to raise fresh points for discussion.

The results of these experiments and of the well known behaviour of richly carbonised iron can only lead us to the belief that not only does the graphite *not* combine with the iron on slowly cooling to 1050° , but that the 2 per cent. of carbon which the solid iron at first contained is rejected as graphite and not as cementite, if the metal is cooled sufficiently slowly. In other words, we are confronted with the highly important fact that carbon is more soluble in iron when it is presented to it as cementite, than when it is presented as graphite. Several analogous cases are known among aqueous saline solutions, in which the dissolved salt can separate in two or more states; either anhydrous (corresponding to the graphitic state of carbon), or containing water of crystallisation (corresponding to Fe_3C). In some of these cases either form of the salt can be made to separate at will from the solution by placing in it a crystal of the desired variety, and this probably throws light upon the conditions under which graphite or cementite separates. Normally, graphite should separate, being less soluble than cementite, but, as was explained in my last paper, graphite is very bulky, and when it is remembered that the mass from which it separates is solid, it will be evident that its separation from the solid will be opposed by a very considerable force: cementite, therefore, and not graphite, is usually found in steel. If, however, flakes of graphite have separated on solidification, as in grey pig iron, these present many nuclei, around which more graphite can form, and thus relieve the mechanical pressure.

Professor Roozeboom in his paper takes the "Phase-Rule" of Gibbs as his guide, and it may be well to consider the subject from this point of view. The phase-rule lays down in effect that in a system such as that of the carburised irons, in which two distinct substances (carbon and iron) are involved, but in which certain forms or phases of carbon or iron, or carbon-iron solution, or carbon-iron compound, are present, no more than two of these phases can exist in equilibrium with each other except at a particular temperature.

In the case of a solution of salt in water, this would mean

remembered that in the case of the salt solution three phases (salt, ice, and solution) could exist together at one particular temperature. In Professor Roozeboom's Fig. 2, the analogous temperature at which cementite, graphite, and solution could exist together was represented by the point E, at which the solubility curve of cementite SE, met that of graphite α E. If, however, as I think we must admit, the solubility of graphite is less than that of cementite, throughout the range of temperature under consideration (900 to 1180), and in the absence of mechanical pressure, the curves cannot meet, and there can be no temperature at which graphite, cementite, and solid solution of carbon in iron can be in equilibrium. The curve of solubility of graphite in iron has been drawn provisionally as α S', because it must pass through α , and the experiments alluded to above suggest that, at somewhat lower temperatures, it approaches closely to the line, AG, of pure iron. As regards the general shape of the curve it is drawn roughly in accordance with the equation of Le Chatelier, and I believe he has already suggested that the curve should occupy some such position. It will be evident from what has already been said that the position of this curve could not be detected by means of the ordinary cooling curves, but it is to be hoped that suitable experiments will be made to obtain its correct position and that of other parts of the diagram which are at present somewhat uncertain.

Equilibrium Curves.

When the evidence with regard to the fusibility of metallic alloys was first obtained by means of a series of cooling curves, the point or points of solidification of each alloy were plotted on a diagram which summarised the results of the whole series of cooling curves, and which was known as a freezing-point curve. The term was retained for a while in connection with the carbon-iron series, although many of the points there represented denoted changes occurring after solidification. A more comprehensive term was therefore needed, and I think that the term "equilibrium curve," which is increasingly used by physicists, will be found to meet the case. Not only does the new term include the changes that occur after solidification, but it also

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represents with a magnification of 56 diameters a portion near the edge of the specimen. It will be observed that the lower part of the figure, which represents the superficial portion of the specimen, has a structure which is entirely different from the rest. A photograph of this portion under a higher power (1580 diameters), Fig. 2, shows ferrite with veins of graphite running through it. The inner portion appears in Fig. 1 to contain a considerable proportion of segregated cementite. A rough determination of the combined carbon by colour showed only about 0.4 per cent., and under the high power objective this portion (Fig. 3) appears to consist almost entirely of a badly developed variety of pearlite, with a little graphite and cementite. How can the different structures in the two portions of the metal be explained? It can scarcely be that the outer portion has been decarburised by cementation in charcoal powder, neither can we suppose that much more carbon has entered by cementation, seeing that it had already been fully carburised by melting in contact with charcoal. The explanation which appears to me to be the most probable one is, that the mechanical pressure which opposes the formation of graphite in the body of the specimen is considerably less near the surface graphite is consequently able to separate, and drains the combined carbon facing the surrounding iron, leaving almost pure ferrite. It is important to remember that the state of equilibrium of two or more bodies is affected by the pressure to which they are subjected, as well as by the temperature. We should, strictly speaking, have a succession of equilibrium curves, each corresponding to a particular pressure. The curves of Professor Roozeboom may well correspond to the true equilibrium of carburised iron when subjected to a considerable mechanical pressure, and that of Roberts-Austen to the somewhat mixed conditions which obtain in practice when both the temperature and the internal mechanical pressure are variable.

SUMMARY.

The general conclusions to be drawn from the inquiry appear to be :—

(1) That carbon is less soluble in iron when presented in the form of graphite than when presented in the form of cementite.

CORRESPONDENCE.

Professor H. LE CHATELIER sent the following communication:—The work of Mr. Bakhuis-Roozeboom on the conditions of equilibrium between iron and carbon is of the highest importance. It is the first time that this question has been fully and fairly met in all its details in a rigorously scientific manner. Ultimately the work that remains to be accomplished will consist in evaluating the numerical values of the conditions, but no change will be made in the ideas founded on them and generally accepted. At the present time it is possible to commence the revision of the details in the light of certain experimental facts which were not known to the author.

1. The curve AB of the solidification of liquid iron given as continuous seems rather as if it should show an angular point, according to the experiments of Mannesmann as well as those more recent ones of Roberts-Austen. This point corresponds to a temperature of 1275° C. and to 2.25 per cent. of carbon. This should be the invariable point corresponding to the equilibrium of the three phases, liquid iron, martensite, and austenite.

2. Mr. Bakhuis-Roozeboom states that the curve AE relative to the equilibrium between the martensite and the graphite cuts the curve E'S at the point E. That is impossible; these two curves are practically parallel and the curve AE tends to intersect the bent line GOS in the neighbourhood of the point O. The line E'S along the whole of its length corresponds with unstable equilibrium. This follows from the observations of Forquignon, Arnold, Osmond, and Royston on the production of graphite during the annealing of steel and iron. The experiments of Mannesmann show that towards 700° C. the saturation of martensite in contact with graphite corresponds approximately with a percentage of 0.5 of carbon, while at the same temperature the equilibrium with cementite corresponds to a percentage which is practically double.

3. The angular point S, which is shown by Mr. Roozeboom as agreeing with previously published work, ought to be removed

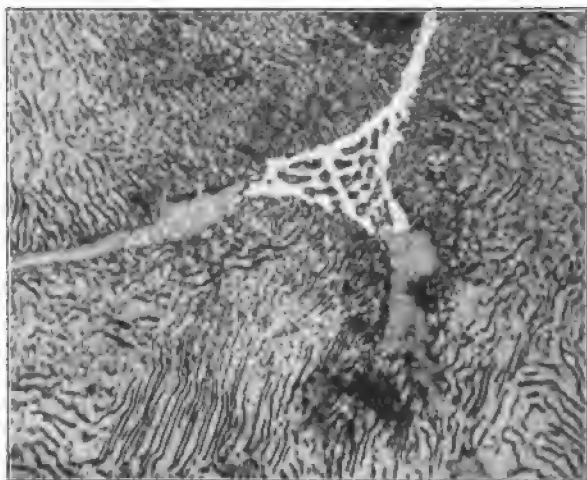
and to be replaced by a small element of curve between two adjacent angular points. As a matter of fact, the writer has shown, by measuring the dilatation, that the phenomena of recalescence is not a simple one, as has been previously considered, but is composed of two successive but entirely distinct phenomena. Experiments on hardening have established that pearlite first changes to troostite, a solid solution of carbon, probably magnetic, and afterwards at a point about 30° higher the troostite is transformed into martensite. There should therefore be a branch of the curve corresponding to the equilibrium of troostite with the martensite.

On the whole, and in fundamental matters, the writer is entirely in accord with Mr. Bakhuis-Roozeboom on the method of representing the phenomena of equilibrium, but he is not convinced, however, that it would not be of interest to duplicate the diagrams in order to render them more easily comprehensible by people who are less familiar with the phase doctrine. On one and the same figure there are curves representative of the composition of different phases of the liquid iron and of the martensite, to which for the sake of completeness the curves of austenite and troostite will also have to be added. That would make it too complicated unless different colours were employed to differentiate the curves. Such a course would give rise to difficulties in printing, and it would be preferable to have distinct figures for each phase, and to place them side by side, in order that the same horizontal line in each will show, as in the author's diagram, the composition of phases in equilibrium amongst themselves. The writer has given an example of this method of representation in an article on the phase doctrine published in the *Revue Generale des Sciences* (vol. x. p. 759) last year.*

Among the consequences of the theory developed by Mr. Bakhuis-Roozeboom there is one which requires some reservations. He indicates that iron of the composition represented by the point *g* would first give crystals of martensite lower in carbon shown by the point *p*. In consequence the iron would become richer in carbon and its melting-point would be lowered. This is rigorously exact, but the alteration in composition and

* See also *Bulletin de la Société d'Encouragement*, vol. vi. 1900, p. 661.

the lowering of temperature only appears at the point represented by the iron s corresponding to a martensite p of the composition identical with that of the iron placed above it. This conclusion, exact in theory, could not always be verified in practice. It supposes that the carbon diffuses in the martensite in such a way that in the centre of the solid mass the crystals first deposited would be constantly enriched in carbon, so as to remain always in equilibrium with the liquid iron. That is true, provided that the cooling takes place very slowly, so as to permit the diffusion of the carbon through the solid mass. If the cooling is not sufficiently slow, the composition of



the iron may descend below the point s , and may even reach the eutectic B' . Matters often seem to progress in this way, as is shown by the appended photograph, which is magnified 700 diameters. The white triangle is the eutectic B' . All around it the pearlite is much more condensed than at a small distance from it. This indicates that the martensite from which it originated had not everywhere a uniform composition.

Baron H. VON JÜPTNER sent the following contribution to the discussion of papers by Professor Backhuis-Roozeboom and Mr. A. Stansfield :—

Published by the American Medical Association, 535 North Dearborn Street, Chicago, Ill.

Subscription price, Five Dollars per Annum in Advance. Single Copies, Fifteen Cents.

Entered as Second-Class Matter, October 3, 1918.

Postage paid at Chicago, Ill., and at additional mailing offices.

Acceptance for mailing at special rate of postage provided for in Act of October 3, 1917.

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and am therefore greatly pleased that this happy result has followed.

In the present paper I should like to dwell upon several points in Roozeboom's beautiful work, in which my views will be set forth after a discussion of the case, and also to touch upon Stansfield's new and interesting publication.

As in the most important part of Roozeboom's paper austenite was not taken into consideration, in the present paper I have chosen the less definite expression "mixed crystals," instead of the expression "martensite mixture of crystals," so as not to anticipate the determination of the boundaries between martensite and austenite, which have not yet been definitely determined.

I. SEQUENCE OF EVENTS ON SOLIDIFICATION.

1. The position of the point a , which naturally determines the whole course of the curve Aa , will first have to be accurately determined experimentally. In the meantime, this point in Roozeboom's Fig. 2 can quite well be taken as accurate.*

According to the original data, the point a lies at 1.2 per cent. of carbon. If one considers that at 1130° C. the quantity of heat liberated must become proportionately less the smaller the quantity of mother-liquor present which solidifies at this temperature, so it is always possible that the point a may correspond to an even smaller percentage of carbon than 1.2.

On the other hand, it is also possible that the point a lies to the right of 1.2 per cent. of carbon, since on solidification, if this does not take place too slowly, it is not impossible that no complete equalisation of the amount of carbon present in the mixed crystals separated from time to time takes place. If an alloy with less than 4.3 per cent. of carbon begins to solidify, mixed crystals with a definite but lower percentage of carbon than the melt itself are separated. In this case the residual liquid portion and also the mixed crystals separated from the same at a lower temperature must contain a higher percentage of carbon.

* The contrary view, taken by Stansfield in his paper, "The Present Position of the Solution Theory of Carburised Iron," Part 2, I cannot at present take into consideration, as in the Le Chatelier formulæ used by him the details of the data are missing, and it is consequently impossible to prove either these or the modifications of them introduced by Stansfield.

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in which expression for temperatures between 1600° and 1250° C. $\frac{a}{a-b}$ is approximately equal to 2.

For lower temperatures the portion remaining fluid at the bend in the curve must be determined; the calculation then follows according to the equation

$$P_1 = P_{1330} \left(\frac{143}{1393 - t_1} \right)^{\frac{a_1}{a_1 - b}},$$

in which $\frac{a_1}{a_1 - b}$ is very close to 1.4.

Though the values of a , a_1 , and b deduced from the graphic construction are certainly not exact, yet an accurate calculation of the process of cooling was undertaken, since even in the event of inaccurate data the general course of the separation, and with it the observed curves of cooling, remain unaltered, and the object of this calculation was only to show to what extent the position of the solidifying point, the proportion of matter separated, as well as the heat liberated in the process, underwent alteration on this assumption.

Between this extreme case and the other of complete equalisation, for which the calculations were also made according to the directions of Roozeboom, the actually observed value must lie, its position depending upon the rapidity of cooling.

(a) *Steel with 0.5 per cent. Carbon.*

| Temperature
in °C. | Fluid Residue (P). | | $\frac{dP}{dT}$ | | Remarks. |
|-----------------------|---|--------|-----------------|--------|--------------------------------------|
| | Without | With | Without | With | |
| | Equalisation of carbon of the mixed crystals. | | | | |
| 1535 | 100.00 | 100.00 | 0.03100 | 0.0309 | Beginning of solidi-
fication. |
| 1525 | 74.48 | 71.79 | 0.02001 | 0.0232 | |
| 1515 | 57.91 | 50.64 | 0.01373 | 0.0181 | |
| 1505 | 46.24 | 34.19 | 0.00981 | 0.0145 | |
| 1495 | 37.83 | 21.03 | 0.00726 | 0.0118 | |
| 1485 | 31.49 | 10.26 | 0.00552 | 0.0099 | |
| 1475 | 26.62 | 0.22 | 0.00429 | 0.0084 | |
| 1450 | 18.43 | ... | 0.00248 | ... | |
| 1400 | 10.33 | ... | 0.00104 | ... | |
| 1350 | 6.59 | ... | 0.00056 | ... | |
| 1300 | 4.55 | ... | 0.00030 | ... | Point of change.
Eutectic alloys. |
| 1250 | 3.34 | ... | 0.00019 | ... | |
| 1130 | 1.26 | ... | 0.00007 | ... | |

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tive proportions of the substances which separate, certain other conclusions may be drawn as to the curves of cooling from the formula for the separation. After the determination of the real curves of cooling, the excess of heat is measured which the substance under experiment gives in consequence of its change of state, compared with one which undergoes no similar change; and as in all cases examined, the heat of fusion of the substance which separates is the cause of this evolution of heat, we are able, under the restricted assumption to which we are led of the heat of melting being but slightly variable, to put the evolution of heat as proportional to the quantity of material separated.

The alteration in direction which a curve of cooling in a given interval of temperature experiences is dependent upon the quantity of matter which separates in this same interval of temperature, and can be expressed by $\frac{dP}{dT}$.

The greater this value is, so much the more sharply must the variation of the curve of cooling separate from that obtained for a substance which cools down without change of state.

From the values calculated for $\frac{dP}{dT}$ in the two cases, we can deduce the following. The commencement of solidification corresponds to the maximum of the alteration of direction, and even in cooling under both the above conditions is quite sharply marked. Referred to this point the observations can scarcely lead to error. The value of $\frac{dP}{dT}$ diminishes with the temperature. This diminution is much more rapid in the case of cooling without equalisation of carbon, and therefore curves must result which give no exact impression of the course of events; afterwards the deviations of the curve from the normal one are only quite trifling. But even in the case of complete equalisation of carbon, that is, in the case of slow cooling, the end of the curve is very indefinite.

We must at once exclude the assumption that the point of change in the curve AB given by Roozeboom corresponds to a sudden increase in the value of $\frac{dP}{dT}$. Since, unfortunately, custom does not permit the publication of temperatures measured, times, &c., but only the curves derived from these observations, I am not in a position to check these results. Should, however, the experimental results afford no confirmation of this assumption,

1. The first part of the paper is devoted to a general discussion of the problem of the existence of solutions of the system of equations

$$\begin{aligned} & \frac{dx}{dt} = f(x, y, z), \\ & \frac{dy}{dt} = g(x, y, z), \\ & \frac{dz}{dt} = h(x, y, z), \end{aligned}$$

where f, g, h are continuous functions of x, y, z and satisfy certain conditions. It is shown that under these conditions the system has a unique solution for any initial conditions.

2. In the second part of the paper the problem of the stability of the solutions of the system is considered. It is shown that if the functions f, g, h satisfy certain conditions, then the solutions of the system are stable.

3. In the third part of the paper the problem of the periodicity of the solutions of the system is considered. It is shown that if the functions f, g, h satisfy certain conditions, then the solutions of the system are periodic.

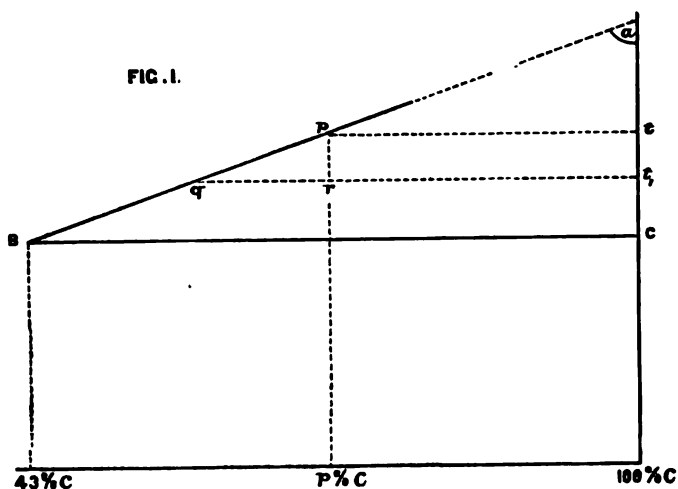
4. In the fourth part of the paper the problem of the bifurcation of the solutions of the system is considered. It is shown that if the functions f, g, h satisfy certain conditions, then the solutions of the system bifurcate.

quantity of the alloy dealt with, and qr the quantity of graphite separated, P , and therefore—

$$P = \frac{qr}{qt_1} = \frac{(t-t_1) tqa}{(100-p) + (t-t_1) tqa}.$$

Here, again, the amount of graphite separated will be greatest at the first moment of cooling, and will diminish by further cooling.

This diminution will, however (since $100-p$ is much larger than $(t-t_1) tqa$), be so small that we can assume with sufficient accuracy that the separation of graphite is directly proportional



to the decrease in temperature. Hence in the case of iron-carbon alloys with 4.3 per cent. of carbon, the point of the eutectic temperature will be less sharply marked than in the case of alloys containing less carbon.

4. Stansfield * has brought forward the hypothesis that about one-half of the carbon dissolved in iron separates on cooling, and uses an equation of Le Chatelier's modified by himself. Unfortunately, it is not stated where the original formula is to be found, and to what extent the modification is justified, so that in this case any discussion is impossible.

* "The Present Position of the Solution-Theory of Carburized Iron" (*Journal of the Iron and Steel Institute*, 1899, No. II. p. 169, and this volume, p. 317).

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1. The first step in the process is to identify the problem or issue that needs to be addressed. This involves gathering information and understanding the context of the problem.

2. Once the problem is identified, the next step is to define the objectives and goals of the project. This helps to clarify what needs to be achieved and provides a clear direction for the team.

3. The third step is to develop a plan or strategy to address the problem. This involves breaking down the problem into smaller, manageable tasks and determining the resources needed to complete each task.

4. The fourth step is to implement the plan. This involves putting the strategy into action and monitoring progress regularly to ensure that the project is on track.

5. Finally, the fifth step is to evaluate the results of the project. This involves assessing the outcomes against the objectives and goals and identifying any areas for improvement or further action.

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It therefore appears that the end-point *E* of the curve *aE* must be placed rather more to the left.

Similarly, Ledebur found that a white pig iron which originally contained no graphite contained after heating for 108 hours—

| | Per Cent. |
|---------------------------|-----------|
| Temper carbon | 1.55 |
| Combined carbon | 0.74 |
| Silicon | 0.87 |
| Manganese | 0.10 |
| | 2.29 p.c. |

Since 0.87 per cent. of silicon is equivalent to 0.37 per cent. of carbon, in this case we have a theoretical amount of total carbon of 2.66 per cent., which is certainly higher than Roozeboom's limit value (1.8 per cent.), but the quantity of separated temper carbon is so considerable that this analysis also appears to favour the shifting of the point *E* previously mentioned.

As we shall see later on, the separation of temper-carbon in the cases we have dealt with may be referred to other causes, so that the position of the point in question may well be possible at 1.8 per cent. of carbon. Circumstances to be dealt with later, however, appear to indicate that the point should be taken for a lower percentage of carbon.

2. According to Roozeboom, another change takes place at about 1000° C., in which the graphite enters into combination with the mixed crystals containing 1.8 per cent. of carbon to produce a carbide (Fe_3C). He indicates this change by the horizontal line *EH* drawn at about 1000° C.

As a matter of fact, Roberts-Austen has found in two experiments retardations in the neighbourhood of this temperature, viz.—

With 2.7 per cent. carbon 1040° C.

With 4.5 per cent. carbon 1000° C.

Further, Osmond and Werth* have already found similar —retardations in very different classes of raw iron, as follows:—

* *Etudes metallurgique; Annales des Mines*, 1888, July-August.

1. The first part of the document discusses the importance of maintaining accurate records of all transactions and activities. It emphasizes that proper record-keeping is essential for transparency and accountability, particularly in financial matters. The document outlines the various methods and tools used to collect and analyze data, ensuring that all information is reliable and up-to-date.

2. The second part of the document focuses on the implementation of these practices across different departments and teams. It provides detailed instructions on how to set up systems for data collection and analysis, ensuring that everyone involved understands their role in the process. The document also addresses common challenges and offers solutions to ensure smooth implementation.

3. The third part of the document discusses the importance of regular communication and reporting. It highlights the need for clear and concise reports that provide a comprehensive overview of the data collected and the insights derived from it. The document also emphasizes the importance of sharing this information with relevant stakeholders to facilitate decision-making and strategic planning.

4. The fourth part of the document addresses the importance of data security and privacy. It outlines the measures that should be taken to protect sensitive information from unauthorized access and ensure compliance with relevant regulations. The document also discusses the importance of regular security audits and updates to ensure that the system remains secure and effective.

5. The fifth part of the document discusses the importance of continuous improvement and innovation. It encourages teams to regularly review their processes and identify areas for improvement. The document also highlights the importance of staying up-to-date with the latest technologies and trends in the field to ensure that the organization remains competitive and innovative.

6. The sixth part of the document discusses the importance of collaboration and teamwork. It emphasizes the need for all team members to work together effectively to achieve common goals. The document also provides tips and strategies for fostering a collaborative and supportive work environment.

7. The seventh part of the document discusses the importance of documentation and archiving. It outlines the procedures for storing and managing data and documents, ensuring that they are easily accessible and secure. The document also emphasizes the importance of regular backups and disaster recovery plans to protect against data loss.

8. The eighth part of the document discusses the importance of training and development. It highlights the need for ongoing education and skill-building for all team members to ensure they are equipped with the necessary knowledge and skills to perform their roles effectively. The document also provides information on available training opportunities and resources.

9. The ninth part of the document discusses the importance of monitoring and evaluation. It outlines the methods for tracking progress and performance, ensuring that the organization is meeting its goals and objectives. The document also emphasizes the importance of regular reviews and adjustments to the plan as needed.

10. The tenth part of the document discusses the importance of communication and reporting. It highlights the need for clear and concise communication throughout the organization, ensuring that everyone is informed and aligned with the organization's vision and mission. The document also provides information on the various channels and methods for communication and reporting.

III. CHANGES TAKING PLACE IN IRON ALLOYS RICHER IN CARBON BETWEEN ABOUT 1000° AND 690° C.

1. The facts quoted above are directly opposed to the assumptions of Roozeboom. According to Stansfield, in iron alloys containing a large proportion of carbon, either graphite or cementite alone is found, while the other of these two constituents is present in negligible quantity. This agrees completely with the phase rule, since the small quantity of the second substance is easily explained by considerations of retardation. Stansfield rightly concludes that, under the conditions obtaining, graphite is the more stable form, which is also supported by the experiment of strongly heating cast iron which originally contained cementite and graphite.

The absence of graphite in most kinds of steel, even after heating, is explained by him (Stansfield) as follows:—A solid solution of carbon in iron, even if considerably supersaturated, does not deposit graphite easily, because as soon as the saturation-point is reached cementite at once separates. The reason for this is, according to his views, that the presence of graphite (from the eutectic alloy), which in iron alloys rich in carbon assists in the separation of graphite, and conversely its absence in iron solutions containing less carbon, acts as an internal pressure to prevent the separation of graphite.

2. Stansfield adduces the following experiment:—Iron was melted together with charcoal powder in a graphite crucible for two days, then heated for one day at a temperature below the melting-point, and then allowed to cool very gradually. The external portion contained ferrite mixed with veins of graphite; the internal portion (slightly magnified) appeared to contain considerable quantities of cementite. A colour-carbon determination gave, however, only 0·4 per cent. of carbon; under a higher power the main portion was recognised as badly developed pearlite mixed with a little graphite and cementite.

An experiment of Ledebur's throws light upon this point. He heated a piece of cast iron containing 2·52 per cent. of carbon, and a piece of malleable iron containing 0·16 per cent. of carbon, both being well packed in wood charcoal in the same crucible. After the heating, the former was found to contain

1. The first step in the process is to identify the problem or issue that needs to be addressed. This involves gathering information and understanding the context of the problem.

2. Once the problem is identified, the next step is to define the objectives and goals of the project. This helps to clarify what needs to be achieved and provides a clear direction for the team.

3. The third step is to develop a plan or strategy to address the problem. This involves breaking down the problem into smaller, manageable tasks and determining the resources needed to complete each task.

4. The fourth step is to implement the plan. This involves putting the strategy into action and monitoring progress to ensure that the project is on track.

5. The final step is to evaluate the results of the project. This involves assessing the outcomes against the objectives and goals and identifying any areas for improvement.

1. The first step in the process is to identify the problem. This involves gathering information about the situation and the people involved.

2. The second step is to analyze the problem. This involves breaking the problem down into smaller parts and understanding the causes and effects.

3. The third step is to develop a plan. This involves deciding on the best way to solve the problem and setting goals and objectives.

4. The fourth step is to implement the plan. This involves putting the plan into action and making any necessary adjustments.

5. The fifth step is to evaluate the results. This involves checking to see if the problem has been solved and if the goals and objectives have been met.

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5. The final step is to evaluate the results of the project. This involves comparing the actual outcomes with the objectives and goals to determine the effectiveness of the project and identify areas for improvement.

Figure 1. The effect of the concentration of the *Agrobacterium* suspension on the transformation efficiency of *Agrobacterium* strains. The number of transformed cells was determined by the number of colonies obtained on the selective medium. The results are the mean of three independent experiments. Error bars represent the standard deviation.

slowly. In this case also we have a solution of carbon in iron in contact with more carbon (viz., the graphite separated), and the dissolved graphite will, in the course of cooling, tend to deposit on the particles of graphite.

The active force is in both cases osmotic pressure, and decarburisation takes place more quickly the greater this force is (that is to say, the higher the temperature and the greater the concentration), the larger the surface of contact between the carburised iron and the graphite (that is to say, the greater the quantity of graphite already separated). On the other hand, decarburisation is limited both by the temperature and by the degree of saturation of the iron.

The decarburisation can, of course, only become complete and attain a condition of stable equilibrium when the cooling is exceedingly slow; yet it is quite certain that loss of carbon must begin immediately the smallest quantity of graphite appears in the alloy, and when the temperature falls so far that the iron carbon solution is super-saturated.

If we consider that, according to Roozeboom, martensite, even at high temperatures, deposits graphite, represented by the course of the line aE , then it is clear that the separation of graphite, which takes place under 1000° , will be represented by the line aE produced.*

4. In order to determine the position of this line more accurately, we have to bear in mind that if steel is heated for a long time to a sufficiently high temperature it deposits its temper-carbon, which within the temperature-interval mentioned, viz., 1000° (or 1030° C.), can neither pass back again into solution nor yet become transformed into carbide. Within this doubtful zone-temperature the free carbon is in a stable condition. From this it follows that the curve of carbon-separation runs from the right at the top to the left at the bottom, and must be placed to the right of and below the cementite curve SE .†

In order to exactly determine the position of the curve we will endeavour to fix two points upon it. The point E must be

* Assuming that temper-carbon and graphite have the same coefficient of solubility.

† Stansfield has drawn the curve (αS_1) above and to the left of SE . According to this supposition cementite would be the more stable condition, which is contradicted by the above facts.

[illegible]

to have a kink. Should it after this point again become rectilinear there are two possibilities to hand. If we alter Roozeboom's line EF , on the grounds previously mentioned, to about 1030° C., the line of cementite separation will cut it at 1.5 per cent. of carbon (instead of 1.80 per cent.). On the other hand, if we take the change martensite + graphite = cementite, and continue the curve of the separation of cementite through this point of change, and through the nearest point determined by Roberts-Austen, and we reach the temperature 1300° at about 1.7 per cent. of carbon. This would indicate that between 1000° and 1030° C. the cementite was the stable condition, whilst below 1000° the graphite would be the more stable. With respect to the point experimentally determined by Roberts-Austen, we prefer, until more experimental results are obtained to assume the latter.

6. The lines PO , MO , OS , SE , and PS represent the conditions of equilibrium existing between iron and carbide of iron; the conditions of equilibrium existing between iron and carbon must be altogether similar. ES we have already determined with a fair amount of accuracy. From the various studies made of cementite, it appears that the eutectic point S_1 at this same temperature (690°) lies near the point S , so that for the present we can take the eutectic line PSK as being the same for both states of equilibrium. The points G and M must remain the same, so that we can well attempt to represent the curve of ferrite separation connected with them by means of the lines GO_1 , MO_1 , O_1S_1 (Fig. 2; in which, of course, the position of the point O_1 is quite hypothetical).

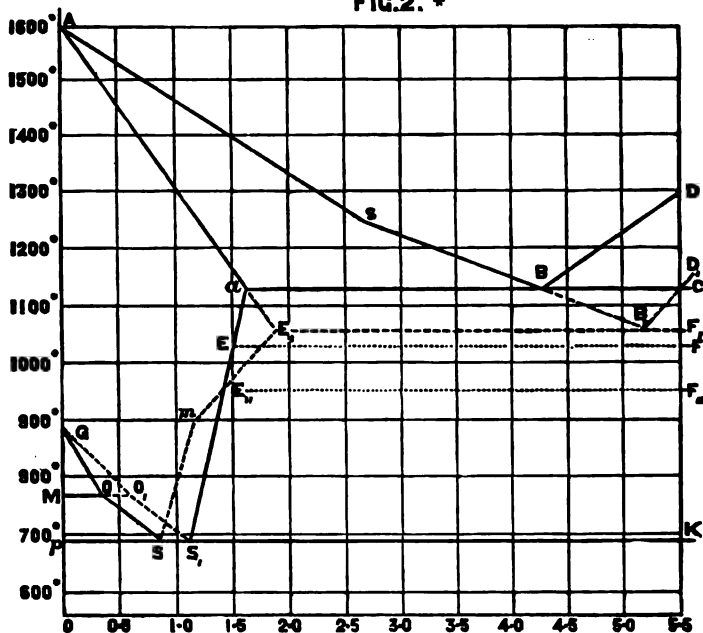
The course of the curves thus drawn corresponds with the assumption that the condition of equilibrium represented in this manner is less stable than that corresponding to the curves of Roberts-Austen. In any case, the results of further experiments must be waited for before the positions of these lines can be more accurately fixed.

7. The conditions of the non-formation of cementite which occur during very slow cooling, and which have already been considered, also explain the formation of temper-carbon by the long-continued heating of steel. On sufficiently long heating, either a direct isothermal conversion of cementite into graphite

are far too incomplete to be subjected to criticism; but the importance of austenite in getting a clear view of the conditions of equilibrium must be fully recognised, since previous considerations having shown what an influence the conditions of cooling produce on the state of equilibrium at higher temperatures, that similar conditions must obtain in the case of lower temperatures.

VII. INFLUENCE OF VARIOUS COOLING PROCESSES ON THE CONDITIONS OF EQUILIBRIUM.

FIG.2. *



The curves already considered have been obtained by the consideration of an ideal stable equilibrium, which, in the case of iron alloys, can be obtained in practice only with the greatest difficulty by extremely gradual cooling. From consideration of

* This figure depends upon the points previously determined. In cases where several possibilities are present, only one is considered, for the sake of clearness. The stable conditions are drawn in lines, the meta-stable (transitional) ones in dashes, and the somewhat doubtful line of change, EF (corresponding to E_nF_n), merely dotted.

the curves AB and Aa , we have already seen how through quick cooling, which prevents the complete equalisation of carbon between the mixed crystals separated at different temperatures, alterations take place in the relative proportions.

In the case of sufficiently quick cooling, the solidifying-point B will be moved to B_1 , by which the position and constitution of the eutectic point must also be moved.

If the cooling is gradually continued till everything has solidified, the solid mass consists of a mixture of mixed crystals having the composition a and of graphite, and by further continued and more gradual cooling the separation of graphite takes place along the line aS_1 . At the temperature S_1 the remaining martensite can be changed either into a mixture of iron and cementite or a conglomerate of ferrite and graphite.

Should, however, the complete solidification have been lowered by quick cooling to the line E_1F_1 , the result of this procedure will probably be (at least in the case of not more than about 5 per cent. of carbon) not a mixture of mixed crystals having the composition a together with graphite, but a conglomerate of mixed crystals having the composition E_1 together with cementite. On further (quicker) cooling, no graphite separates, but only cementite (along the line E_1mS).*

If, on the other hand, as has previously been assumed, the solidification follows a course corresponding to the line aC —that is to say, slowly—and if from this point further cooling takes place at a medium rate of speed, then it follows that with a low percentage of carbon (under 1.4), the graphite separation takes place along the line aE'' , and the cementite separation along the line $E''mS$; or with a still lower percentage of carbon, ferrite separation along the lines GO and OS . Should the cooling take place more rapidly, the separation of cementite and of ferrite does not take place, and we have below PSK martensite produced (hardened steel).

We must not lose sight of the fact that, just as by the equilibrium between iron and iron carbide along the line PSK , martensite is changed into pearlite (a mixture of ferrite and cementite), so by the equilibrium between iron and carbon, the

* On very gradual cooling graphite (or temper-carbon) would be capable of separation only below E'' .

conversion of martensite into a mixture of ferrite and graphite is conceivable. Whether, and under what conditions, this process is capable of realisation, further experiment will show.

The sequence of events on heating is naturally the reverse of those on cooling. Thus heating to a little over 690° suffices to convert steel hardened (that is to say, containing martensite), if followed by slow cooling, into steel containing pearlite.

If steel containing separated cementite is heated, then, as has been seen previously, one of two things must take place; either the cementite may be converted isothermally into graphite, or else it may go into solution, whence, on slow cooling, it may be again separated as cementite, as, in consequence of the presence of such small quantities of cementite, the separation of this form is necessitated.

In this case, the separation of carbon can only take place if, on heating the temperature, E_1 has been attained. Whether this is really the case depends upon the circumstance whether, at the first moment of solidification, graphite or cementite is separated. The case is then quite analogous to the behaviour of a solution of sodium sulphate, which, according to whether it is brought into contact with crystals of $\text{Na}_2\text{SO}_4 \cdot 10\text{H}_2\text{O}$, or $\text{Na}_2\text{SO}_4 \cdot 7\text{H}_2\text{O}$, separates different salts from the same solution.

After our views of metallic alloys, and especially of iron-carbon alloys, have been so greatly extended by means of theoretical and physical chemistry, the experimentalist comes once more to the front, in order—it may be by means of a fundamental study of curves of cooling, of dilatation, &c., or through the application in this direction of various chemical and microscopical researches—to determine, so far as possible, the exact position of various points of change and curves deduced from them, and also the numerical data that these give rise to.

These experiments must certainly be frequently repeated under varying conditions, especially as regards time, since it is very possible, especially in the chemistry of iron, that meta-stable (transitional) conditions occur, and only experiments frequently repeated, and extending over a long period of time, will yield a satisfactory result.

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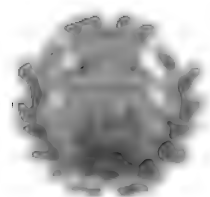
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line SE, and there would be a quantity of free cementite. If now the line aS' , which shows the solubility of free carbon in iron, lie to the *left* of SE, as I have drawn it, it is evident that the iron containing 1.1 per cent. of dissolved carbon would be supersaturated with respect to free or temper carbon, and that if sufficient time were allowed, and the conditions were otherwise suitable, free carbon would separate from the iron until the latter only contained about 0.5 per cent. of carbon as indicated by the line aS' . The iron would then be in a condition to dissolve some of the free cementite, and these processes would continue until the whole of the free cementite had been replaced by free carbon.

This argument appears to me to show that any temperature at which free carbon is more stable than free cementite, the curve aS' , denoting the solubility of free carbon, must lie to the left of the curve SE, which denotes the solubility of cementite.

I should have been glad if Baron von Jüptner had pointed out the flaw in this argument, as he appears to arrive at a different conclusion. Perhaps, however, the wording in my paper was not quite clear, and has thus led to misunderstanding.

The remainder of Baron von Jüptner's communication deals mainly with the paper of Professor Roozeboom, but I am glad to notice the importance which he attaches to the influence of the rate of the cooling which necessarily follows all experiments at high temperatures, and the advisability of making a number of fresh experiments under conditions indicated by the theoretical work.



The proceedings on September 18 began with great punctuality, and the Council had every reason to be satisfied with the support they received from members, as evinced by the large attendance, the spacious hall of the Société d'Encouragement being filled to overflowing a few minutes after 9.30 A.M. On the second day, also, the business of the Institute meeting was begun in good time, the attendance being again large.

VISIT TO THE PARIS EXHIBITION.

During the afternoons of September 18 and 19 the Exhibition was visited, where groups were formed under the guidance of experts for the purpose of examining the various sections of metallurgy, mining, and machinery.

The Paris Exhibition of 1900 covered a larger area than any Exhibition previously held in that city. The site occupied comprised the Champ de Mars, the Esplanade des Invalides, the Trocadéro Gardens, a portion of the Champs Elysées, the quays on both sides of the Seine, between the Alexander III. Bridge and the Pont d'Jena, and the Park at Vincennes.

The total superficial area was as follows:—

| | |
|--|-----------|
| Champ de Mars | 124 acres |
| Esplanade des Invalides | 30 „ |
| Trocadéro Gardens. | 40 „ |
| Champs Elysées | 37 „ |
| Quays on the left bank of the Seine | 23 „ |
| Quays on the right bank of the Seine | 23 „ |
| Park at Vincennes | 272 „ |
| Total | 549 „ |

The superficial area occupied by buildings and covered in is believed to have amounted to 4,865,328 square feet, distributed as follows:—

| | |
|-----------------------------|-----------------------|
| French Sections | 2,691,000 square feet |
| Foreign Sections | 1,829,880 „ |
| Park at Vincennes | 344,448 „ |
| | <hr/> 4,865,328 |

The strip of land on each side of the Seine devoted to the Exhibition extended for a distance of $1\frac{1}{3}$ mile. About one hundred French and seventy-five foreign pavilions and detached buildings were erected in the grounds, without counting the thirty-six official pavilions of nations participating in the Exhibition; these official pavilions were

VISIT TO THE LE CREUSOT PAVILION.

The visit of the Institute to Paris could not have been complete without an inspection of the Le Creusot Pavilion, and the invitation of Mr. Eugène Schneider to a reception in this building (on Tuesday afternoon, September 18) was therefore exceedingly welcome, and was very generally taken advantage of, both by the members themselves and the ladies accompanying them. A number of engineers belonging to the works acted as guides. Several of them spoke English fluently, and this rendered the visit all the more instructive to many of the members. On the occasion of the Institute's visit the Pavilion was closed to the general public, and Mr. Eugène Schneider, the head of the firm, assisted by Mr. G. Canet, received the visitors at the entrance.

THE LE CREUSOT PAVILION.

The Le Creusot Pavilion, a huge dome-shaped building, 141 feet in diameter and 130 feet in height, crowned with a campanile 13 feet in diameter, might have been taken for a massive armoured fort with its projecting guns. The roof was constructed of three-hinged trusses of H-section, forming twenty-four ribs, 18 feet apart at their feet and converging to a special spherical bearing in the centre at the top of the dome. The upper part was roofed with wood and plaster painted red, and the lower part was glazed. As the Moulineaux Railway ran through the building, half of the floor space on the side away from the river Seine was raised to a higher level and carried on girders of 56½ feet span resting on walls built outside the walls of the railway cutting and independent of them, so as to carry the weight of the exhibits with safety. On this raised portion were exhibited a large number of different types of guns and mortars, while the lower part of the building contained the engines, locomotives, and electric plant, besides armour plate. The cannon ranged in size from the 24-centimetre gun with its armoured turret, for the Spanish navy, down to the 10-centimetre quick-firing guns and 75-millimetre field-pieces, and even smaller. The breech mechanisms were of numerous types, and in some of them a single movement was all that was required to unlock and throw out the breech block. Hydraulic and electric gearing were both shown in operation for manipulating the guns and their mountings, &c., while the recoil

150-ton electric crane, and a 10,000 ton press is available for compressing liquid ingots, the only plant of its kind in France. Rotary puddling furnaces are used for the preparation of exceptionally pure material used in the manufacture of guns and armour plate. In the forge there are seven steam-hammers, ranging from 20 to 100 tons, each served by its own furnaces and cranes and four forging presses rated at 1500, 2000, 3000, and 6000 tons. The 100-ton hammer is really to be considered of 120 tons, and it is served by four furnaces and four cranes of 100 to 160 tons. It is used for forging armour plate up to 24 inches in thickness and 65 tons in weight. For tempering gun tubes, a well 65½ feet deep is provided, besides all appliances for treating armour with oil or water tempering processes. Three overhead travellers of 100, 80, and 40 tons are used for handling the work in this department. A recently built tire mill is capable of turning out 12,000 to 15,000 tons of tires of all sizes annually.

In the rolling-mills there are some 140 engines with a total of 12,000 horse-power, and from 120,000 to 140,000 tons of finished products are made yearly, ranging from merchant iron $\frac{1}{4}$ inch in diameter to armour plates of 40 tons weight. For merchant and section iron and steel there are twelve three-high mills and four trains for plates and sheets, besides a special mill for fine sheets. The present armour plate mill is to be supplemented by a new one capable of handling work up to 60 tons in weight.

Of the extent of the various manufactories for finished articles it would be hopeless to give any idea within the limits of a short note, but the various appliances shown at the Exhibition and referred to above will indicate some of the capabilities of the Company.

THE SOIRÉE MUSICALE.

The *Soirée Musicale* given on Tuesday evening, September 18, by the Comité des Forges de France was organised in a masterly way, and carried out royally. From first to last it was a most interesting and successful function, greatly owing to the way in which every detail had been studied. The Local Reception Committee, headed by its president, Mr. Robert de Wendel, were evidently sincerely pleased to have the opportunity of entertaining the members and the ladies accompanying them. One may also safely say that the ladies and members enjoyed quite as much the pleasure of being the guests of the Comité. The programme had been drawn up with a skill that

BANQUET AT THE HOTEL CONTINENTAL.

On the evening of September 19 the Institute entertained the Reception Committee at a banquet at the Hôtel Continental. Sir William Roberts-Austen, K.C.B., President of the Institute, presided, and 250 members and their friends were present. The guests who accepted the invitation of the Institute were Messrs. Robert de Wendel, President of the Comité des Forges; E. Schneider, Vice-President; Baron de Vaufreland, Treasurer; H. Pinget, Secretary; C. Boutmy, Lesaffre, G. Baty, and A. Sepulchre, Members of Council; A. Gigot, La Ferté, and Paraf, Honorary Members of the Comité des Forges; G. Canet, President of the Société des Ingénieurs Civils; the President of the Municipal Council of Paris; A. Lodin, P. Arbel, Brustlein, A. Chappée, and F. Raty, members of the metallurgical jury at the Exhibition; Vesier, President of the Compagnie Française des Métaux; Demenge, managing director of the same company; Gény, managing director of the Le Creusot Works; Buquet, director of the Ecole Centrale; Sauvage, chief engineer of the Western Railway Company; Baudry, chief engineer of the Lyons Railway Company, and Solacroup, chief engineer of the Orleans Railway Company; Bonnassies, of the St. Chamond Company; and François de Wendel, Dutreux, Ast, and Charvet, engineers, who kindly acted as guides at the Exhibition. The British guests included Colonel Jekyll, the British Commissioner at the Exhibition, and General Festing, C.B.

The PRESIDENT, in proposing "Her Majesty the Queen," said: "I will only add, for I wish to be very brief to-night, that tenacity and endurance, attributes of steel, are precisely the qualities we should wish to possess were it necessary for us to express our devotion to Her Majesty. Gentlemen, I give you the health of the Queen—God bless her."

The PRESIDENT again rose and said: "We have come to France to express our homage to this great country on the occasion of the splendid International Exhibition which so nobly crowns the century. France has always been a paradise. I love her with all my heart. I am sure you will drink with every sign of enthusiasm to the President of the French Republic."

The PRESIDENT again rose and proposed a toast of cordial fraternity. He said: "I rise to propose 'Our Guests,' and to this toast I will add the name of the President of the Comité des Forges de France. There are one or two others I would specially mention.

1. The first step in the process of creating a new product is to identify a market need. This involves conducting market research to understand the preferences and behaviors of potential customers.

2. Once a market need is identified, the next step is to develop a concept. This involves brainstorming ideas and creating a prototype that demonstrates the basic functionality of the product.

3. The third step is to conduct a feasibility study. This involves evaluating the technical, financial, and operational aspects of the product to determine if it is viable for production.

4. If the feasibility study is successful, the next step is to develop a business plan. This involves outlining the marketing strategy, production process, and financial projections for the product.

5. The final step is to launch the product. This involves manufacturing the product, distributing it to retailers, and promoting it to the target market.

language will put me in mind of the happy years I spent in your country, where I had the good fortune to learn my trade in a technical point of view, and also the English ways of doing business. All this has been so useful to me in life that I shall never forget it. In June last I had the great honour and pleasure to receive, as President of the Society of Civil Engineers of France, delegates of your Institute, at the head of whom was your honourable President, Sir William Roberts-Austen, and it is a great pleasure for me to be received in my own country by your President and such a large number of your members. We civil engineers of France follow with keenness your numerous and remarkable works of research. It is you who in a sense give us our daily bread in the shape of good steel and iron, for without these the industry of life is bound to decay. Your discoveries are the basis of all engineering works and form, and it is therefore with a heartfelt pleasure that we welcome you to Paris, the eminent representatives of the first Institution, and I invite you all to drink the health of your honourable and learned President, Sir William Roberts-Austen."

The PRESIDENT, in reply, said: "What am I to say? I can only say that I thank you from the very depth of my heart, and that the one event of my life to remember with pride is that you came in such numbers to France, the land we English love so much. I will say nothing more except to tell you how glad we are that Mr. Canet learned anything from us. How much we have learnt from France—how much I owe to her, will be revealed by the address which I did not read the other day. I have nothing to add from a full heart except my most grateful thanks."

VISIT TO THE EXHIBITION AT VINCENNES.

On September 20 the members visited the portion of the Exhibition at Vincennes. The "Annexe" of the Exhibition was situated to the east of Paris in the Park of Vincennes. It included the Daumesnil lake, and was bounded by the fortifications between the Charenton Gate and Picpus Gate, by the Avenue Daumesnil between the Picpus Gate and the road to Saint-Mandé, and by the road to Gravelle. It was reached (1) by the Vincennes Railway from the Place de la Bastille; (2) by the Ceinture Railway to Rue Claude Decan Station; (3) by the steamers of the Compagnie des Bateaux-Parisiens to the Pont de Charenton; (4) by the Louvre-Charenton Tramway to the Pont de Charenton; and (5) by Electric Tramway from the Bastille to Charenton. The objects

AMERICAN MEDICAL ASSOCIATION
PUBLISHED WEEKLY
CHICAGO, ILL., U.S.A.

Subscription price, Five Dollars Per Annum in Advance

Single Copies, Fifteen Cents

Entered as Second-Class Matter, October 3, 1899, under Post Office No. 363, at Chicago, Ill., under special rate of Post Office Department, approved October 3, 1899.

Acceptance for mailing at special rate of postage provided for in Act of October 3, 1917.

Postage paid at Chicago, Ill., and at additional mailing offices.

Postmaster: Send address changes in full to JOURNAL OF THE A. M. A., 535 N. Dearborn St., Chicago 10, Ill.

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Printed at the University of Chicago Press, Chicago, Ill.

Second-class postage paid at Chicago, Ill., and at additional mailing offices.

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THE EXCURSION TO LORRAINE.*

The ironworks at Hayange, Moyeuvre, and Stiring Wendel, belonging to Les Petits Fils de François de Wendel et Cie., were visited in 1878 by a group of members of the Iron and Steel Institute. Since that date the introduction of the basic process has led to the closing of the Stiring Wendel Works, of which the speciality was the manufacture of iron rails, and three basic steelworks have been established, one at Hayange (Germany), the second at Moyeuvre (Germany), and the third at Joeuf (France). These works are situated at the northern end of the oolitic iron ore region in the neighbourhood of Longwy and Thionville, and all the iron is made from the minette ores of the locality, but the coke is imported from Westphalia. During the year 1899-1900 these works produced—

| | Hayange and
Moyeuvre. | Joeuf. |
|---------------------------|--------------------------|---------|
| | Tons. | Tons. |
| Pig iron | 477,600 | 193,000 |
| Rolled products | 298,000 | 125,000 |

Twenty members of the Institute, who had left Paris overnight and arrived at Metz early in the morning of Friday, September 21, were met at Ueckingen by Mr. Henri de Wendel and his sons, and conveyed by one of the works trains to the steelworks at Hayange, and then to the blast-furnaces and steelworks at Joeuf. After an adjournment to lunch at the adjacent chateau, the train was again taken on to the rolling-mill plant at Jamailles, and finally returned to Metz in the evening. During the adjournment, in reply to some remarks by Mr. E. P. Martin, Past-President, Mr. Henri de Wendel gave some interesting retrospective particulars of the works as follows:—

“Gentlemen, in the year 1879, on the occasion of the Paris Exhibition, I had the honour of entertaining at Hayange a group of members of the Iron and Steel Institute. It is a great satisfaction to the members of our firm and our collaborators to see twenty years later a new party of the Institute coming here again. This circumstance leads us to think that the impression of your previous visit had not left a bad remembrance on your minds. I am more anxious, however, about the present visit. When you came in 1879 our plant was a new one. You saw at work fifty puddling-furnaces fitted with mechanical puddlers, with a production of 400 tons of puddled bars in

* Report kindly furnished by Mr. H. G. Graves, Assoc. R.S.M.

1. The first part of the document is a title page. It contains the title "THE HISTORY OF THE UNITED STATES OF AMERICA" and the author "BY JAMES M. SMITH". It also includes the publisher's information: "NEW YORK: PUBLISHED BY J. B. LIPPINCOTT & CO., 15 N. 2ND ST. 1854."

2. The second part of the document is a preface. It begins with the words "TO THE READER" and discusses the author's purpose in writing the book. It mentions that the book is intended for the general reader and that it is written in a simple and plain style.

3. The third part of the document is the main body of the text. It begins with the words "THE UNITED STATES OF AMERICA" and continues with a detailed history of the country. The text is written in a simple and plain style, as mentioned in the preface.

4. The fourth part of the document is a conclusion. It begins with the words "THE UNITED STATES OF AMERICA" and continues with a summary of the main points of the book. It also includes a list of references and a list of names.

5. The fifth part of the document is an index. It contains a list of names and subjects, with page numbers indicating where they can be found in the book.

transferred from one side of the bay to the other. The converters take charges of 13 tons of metal from a mixer supplied from the blast-furnaces, and the steel is cast into four 3-ton ingots, which are sent through gas-fired soaking pits to the cogging-mill, driven by a twin compound engine built in 1895. The sheared ingots are transferred by an overhead traveller to a large central reheating furnace, into which they are pulled by a chain led round a guide-pulley to a vertically-acting hydraulic ram. From the opposite side of the furnace they are discharged on to a line of live rollers, which lead them to the finishing-mill. Beyond this are extensive cooling-beds, with rope-hauling appliances. The same building also contains the two-high reversing bar-mill, driven by a three-cylinder engine. On one side is a long inclined shoot, and on the other side live rollers followed by an electrically-driven shearing-machine. The live rollers here are driven in a most ingenious manner. The axles of the rollers run between horn-plates, so as to have a slight vertical play, and the rollers themselves lie on two endless running ropes, so as to get a frictional drive. The mills are of the ordinary two high-class mill reversing engines of a type familiar in this country, with hydraulic side traversing gear and steam-driven live-roller trains, and as such calling for no special remark. What is, however, of interest is the liberal manner in which the plant has been designed, the mills and their engines being so arranged as to meet sudden demands for very rare sections without having to stop for changing rolls, i.e. separate mills are kept ready for each class of work, so that the stuff can be transferred from one to the other as required without delay. An example of this flexibility in working was given to the visitors, who, during the short period of their visit, saw joists about 15 inches deep, wire billets, and medium-sized angle bars rolled successively by the same set of men in the different works.

THE WORKS AT JOEUF.

At Joeuf there are six blast-furnaces, of which five were in blast and one under repair. Each makes 100 to 120 tons daily, being equipped with four tall and narrow Cowper stoves each, and supplied with blast at 200 millimetres of mercury pressure. No water plates are built into the furnaces, which are, however, cooled externally by flowing water in large quantities. The average fuel consumption is 23 cwt. per ton of iron. The age of these furnaces differs considerably, and one has been in blast for seventeen years. The pig-beds are







1943-1944

1945

1946-1947





1917-18-19

1918-19

1919-20



1954

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THE ROLLING-MILLS AT JAMAILLES.

At the mills at Jamailles nearly a hundred thousand tons of section and merchant steel of all kinds are rolled annually; and the works are crammed to the utmost with long trains of three-high rolls all in full activity. Small mechanically operated lifting-tables were in general use at the rear side of the mills, but for very light sections all the manipulation is done by hand. As at the other works, nearly all the supplementary machinery is driven by electromotors with continuous currents at 250 volts.

EXCURSION TO ST. CHAMOND.*

The St. Chamond Works is one of the properties of the *Compagnie des Forges et Aciéries de la Marine et des Chemins de Fer*, a company which originated in 1837, and since then has passed through various stages of progress, until at the present time it has a capital of twenty million francs, and is possessed of the following properties in addition to St. Chamond:—Iron and steel works at Assailly (Loire), at Rive-de-Gier (Loire), at Givors (Rhône), and at Boucau (Basses-Pyrénées); collieries at Unieux and Fraisse (Loire); iron mines at Ougney (Jura), at Saint Léon (Sardinia), and at Lamiari and Montoya (Spain); forests in Corsica, and important concessions for iron ore at Chevillon (Meurthe-et-Moselle). In ordinary times from 8000 to 10,000 work-people are employed by the Company, and large sums of money are annually expended in the improvement and development of the equipment and in erecting new workshops, at the present time under the direction of Mr. J. Girard and Mr. Leroy. Most diversified, too, are the products:—Sections, rails, metal sleepers, and small materials for the permanent way at Boncau, visited by some members of the Institute in 1896. Forged locomotive and waggon wheels of all patterns, parts of marine machinery, stern-posts, rudders, &c. at Rive-de-Gier. Railway springs, specially light wheels, and delicate thin steel sheets at Assailly. Field, siege, and battery artillery, naval guns, cannon of all calibres, ammunition and projectiles, armoured turrets and towers for coast defence, for war-ships and for land forts, armour-plates, propeller and crank shafts, rails, tires, sections, forgings, steel axles, iron and steel frames, and all kinds of plates and sheets for railway rolling stock and general purposes, is the long list of things manufactured at

* Report kindly furnished by Mr. D. A. Louis, F.I.C.

[illegible]

sleeping-car, the time was altered almost at the last moment to 7.20. The announcement of the change was circulated as freely and quickly as possible, with the result that most of the participants dined together at the Lyons Station in Paris previous to departure, and were comfortably and agreeably installed in the sleeping-car; two members, however, who had not heard of the change of time, followed by the original train, but arrived at St. Etienne at the same time as the others. After breakfast at St. Etienne the party proceeded by train to St. Chamond, where they were met at the station by Mr. A. de Montgolfier, the managing director, amongst others, and after a few words of welcome, were taken in conveyances to the works. In the office Mr. A. de Montgolfier introduced Mr. Henry de Montgolfier, director of the works and chief engineer, Mr. Joseph de Montgolfier, engineer at Paris, and other gentlemen whose names will be mentioned in connection with their departments, where they officiated as guides. Mr. A. de Montgolfier then explained the day's programme, which, under the admirable leadership of Mr. Henry de Montgolfier, was punctiliously carried through, and was rendered interesting and valuable by the readiness with which he himself and the various others who accompanied were at all times ready to furnish any information required. Another noticeable and agreeable feature of the visit was the absolute openness of everything; there was no door marked private, and no forbidden entrance or barred passage, but the "open door" policy was most freely practised.

The course followed on the present occasion is indicated by the order of the lettering on the plan, Plate XXV., and a start was made with a hasty walk through yards and passages, but not too hasty to prevent the observation of the good order which prevailed everywhere, even to the scrap heaps—an orderliness, moreover, that was not restricted to the exterior, but was to be remarked throughout the various shops, both great and small, subsequently visited; and what perhaps was still more remarkable was the smoothness with which the various big operations witnessed were conducted, a few simple signals sufficed in all cases for directing manipulation without bustle or confusion. The shop A was the first visited; it is the great forging shop, a lofty, imposing, spacious structure, intended for exceptionally big as well as smaller work, such as the manipulation of ingots for cannons, armour-plates, &c.; it comprises two big halls 262 feet long and respectively 98 feet and 82 feet wide, with an intermediate smaller hall of the same length, but 33 feet wide, the whole under the direction of Mr. Breton. In the

1. The first step in the process is to identify the problem or issue that needs to be addressed. This involves gathering information and understanding the context of the problem.

2. Once the problem is identified, the next step is to define the objectives and goals of the project. This helps to clarify what needs to be achieved and provides a clear direction for the team.

3. The third step is to develop a plan or strategy to address the problem. This involves breaking down the problem into smaller, manageable tasks and determining the resources needed to complete them.

4. The fourth step is to implement the plan. This involves putting the strategy into action and monitoring progress regularly to ensure that the project is on track.

5. Finally, the fifth step is to evaluate the results of the project. This involves assessing whether the objectives have been met and identifying any lessons learned for future projects.

pieces of artillery and munitions of war. The special designs of Messrs. Darmencier and Dalzon were particularly admired. These engineers direct the artillery department, and it is they who have done so much to make the St. Chamond patterns celebrated both in France, our own, and other countries.

Shop C is also 492 feet long and is 105 feet wide, with a central alley 60 feet wide and two side alleys 23 feet wide, with galleries above. There are two 60 and two 10-ton electrical overhead travelling cranes. The central alley of this shop is arranged particularly for that work that has to be done when the parts are in position, and here were to be seen some of the Company's specialties in course of construction—trunks for ships' barbettes, fixed and revolving turrets, gun mountings for turrets and forts; the riveting, boring, final dressing, and fitting into position of the armour-plates of these structures was in progress, and the subsequent final touches were being given. To accommodate these great pieces of work there are many special platforms, and also to give the necessary height or for convenience of access pits are sunk in the floor and scaffoldings are erected, or there are masonry walls to support the work where necessary, as, for instance, in the case of a trunk for a barbette which was under treatment. The tools, mostly electrical, are clamped on standards or otherwise adjustably supported so as to reach any part of the work, and three or more tools could be seen in operation on different parts of the same work simultaneously. Many of the tools were of special character and design, and the precision of the work in this department was most striking. The varied and curious forms the plates had to have, the exact way they were fitted together, and the care with which even very slight imperfections were removed, particularly attracted the attention of the visitors. The boring and riveting machines for unmounted ship and boiler plates were arranged in the side alleys.

In the shop marked D, which has a 60-ton traveller, were arranged boring machines for guns and lathes for guns and shafts, and were most of them at work.

The next shop visited, E, covers an area of $2\frac{1}{2}$ acres, and has three 30-ton overhead travellers and many locomotive cranes. Here the various parts of guns, carriages, and mountings are assembled and finished, and at the far side are fitted and the finished work erected. This shop was at full work, and with the vast number of machines presented a very busy and interesting scene. This department can turn out a field-gun, fully equipped with ammunition carriage, &c.

一、總論

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（二）範圍

（三）對象

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二、實施

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metal was drawn from two furnaces, one on each side, simultaneously, and was run into a stationary ladle, from which, after a period of repose, it was drawn off at a definite rate into the ingot mould. Particular attention is paid not alone to the selection of the material for the steels, but also to the temperature of the bath, to the time occupied in filling the mould, and to the dimensions of the mould employed. Adjoining the steelworks is the steel-foundry H, with one 150 and two 30-ton travelling cranes. It is capable of dealing with the heaviest as well as lightest castings, and has a capacity of 100 tons of castings a month. Messrs. Pernot and Bourgeois were the engineers in charge of the steel department.

The next visit was to the armour-plate cementation and tempering houses, I and J. In the first of these, depicted in Fig. 2, there are five great furnaces for the cementation of Harvey and Krupp plates; from one of these a curved plate for a turret was withdrawn and slung horizontally on to a tabular spraying frame, the jets being at once set to work; a similar frame running on rollers was then brought into position over the plate, coupled up to the water supply, and the jets immediately set to work, so that the plate at all parts of its surface was subjected to a copious but evenly distributed play of water. All the operations were conducted with rapidity, but without any confusion. The arrangement is represented at work in the centre of Plate XXIV.

In the next house a bent armour-plate for a "blockhouse" was withdrawn from a furnace in a vertical position, and slung and plunged into the water-tank in the same position. In this house are the heating and annealing furnaces, and also the shaping presses, two in number, one about 3000, the other 3500 tons. Both are served by two 60-ton travelling cranes; the former is used for shaping before tempering, the latter to give the finishing touches after tempering, and, if necessary, the great 6000-ton press already referred to is brought into requisition. With these machines plates are given most complicated forms without any danger to the quality of the metal.

The next surprise for the visitors was a view of the new mill in course of erection at K. The rolls, housing, live rollers, and parts of the engine and the building were in place, and it is supposed that the mill will be complete in November. It has been constructed to cope with the requirements of the present day, and consists of an armour-plate mill with rolls 15 feet long and sheet-mill with rolls

1. The first step in the process of the scientific method is to make an observation or ask a question.

2. Next, a hypothesis is made, which is an educated guess about the answer to the question.

3. Then, the hypothesis is tested through an experiment.

4. After the experiment, the results are analyzed to see if they support the hypothesis.

5. Finally, a conclusion is drawn based on the analysis of the results.

or material employed for the making of gun-steel. The furnaces have a separate melting bed and a rotating puddling-hearth; they work charges of a ton each, and the output reaches as much as $8\frac{1}{2}$ tons in twenty-four hours.

The final item in the programme before lunch was the witnessing the tempering of a gun-tube. This took place in the house specially devoted to that purpose, O on the plan. The most striking feature is the great tempering-pit, measuring about 130 feet by 85 feet by 69 feet deep from floor level. In the bottom of this pit there are several wells; the deepest, 72 feet and 10 feet in diameter, serves for tempering large work, such as big gun tubes, which attain at times nearly 50 feet in length; whilst the smaller baths or wells are used for light guns. Two of the smaller ones are in communication with the larger one, and are furnished with centrifugal pumps, in this way rendering by circulation upwards of 44,000 gallons of oil available for the tempering of large guns. At one end of the pit is the vertical reheating furnace, 69 feet high, with six super-imposed firing grates. A 50-ton travelling gantry running on rails on the floor level serves for manipulating the work; it is provided with steam windlass for doing the lifting operations and hydraulic tackle for controlling the lowering—this is to ensure rapidity with steadiness. The various stages in the operations were keenly watched—the opening of the furnace, lifting the work out (a 12-inch gun-tube), travelling it across, centring it over the bath (water in this instance), and lowering it, the whole being done with considerable expedition, and without causing the gun-tube to sway or swing. The gun-metal before tempering has a resistance of 40 to 60 kilos. per square millimetre, with a minimum elongation of 18 per cent.; after tempering the resistance is 54 to 80 kilos., with the elongation from 12 to 14 per cent. On the floor level, in convenient proximity to the tempering-pit, there are heating furnaces for small guns and for gun-rings, and a 10-ton steam crane running on a broad gauge track. An annex is attached to this house, which is equipped for the tempering and annealing special armour-piercing shells and other projectiles, for which the works are famous the world over. These are, in fact, one of the great specialties of the works. They are made of extra hard crucible steel, are vigorously hammered, and submitted to processes of tempering and annealing peculiar to this Company. Messrs. Marchais and Chalon are the engineers in charge of the tempering operations.

A return was now made to the offices, whence the carriages drove

1. The first step in the process of the development of a new product is the identification of a market need. This is often done through market research, which can be conducted in a variety of ways, including surveys, focus groups, and interviews. The goal of market research is to gather information about the needs and preferences of potential customers, as well as to identify any gaps in the market that a new product could fill.

2. Once a market need has been identified, the next step is to develop a concept for the new product. This involves brainstorming ideas and creating a rough sketch of the product. The concept should be based on the market research and should address the needs of the target market. It is important to have a clear idea of what the product will look like and how it will function before moving on to the next step.

3. The third step in the process is to create a prototype of the new product. A prototype is a small-scale model of the product that is used to test the concept and to gather feedback from potential customers. It can be made using a variety of materials, including cardboard, wood, and plastic. The prototype should be designed to look and function like the final product, but it does not need to be perfect. The goal is to get a sense of how the product will be received by the market and to make any necessary adjustments before moving forward.

4. Once a prototype has been created, the next step is to conduct a pilot test. This involves selling the product to a small group of customers and gathering feedback on their experience. The pilot test is a crucial step in the process, as it allows the developer to see how the product performs in the real world and to make any necessary adjustments before launching the product on a larger scale. It is important to listen to the feedback from the pilot test and to be willing to make changes if necessary.

5. The final step in the process is to launch the new product. This involves creating a marketing plan and promoting the product to the target market. The marketing plan should include a variety of strategies, including advertising, public relations, and sales. The goal is to create awareness of the product and to generate interest among potential customers. Once the product has been launched, it is important to continue to monitor the market and to make any necessary adjustments to the marketing plan.

deflection. The hydraulic recoil gear in this case is carried under the gun, which is mounted on a sliding seating upon which the gun travels at the recoil, but is immediately brought back exactly into position by the gear, the men attending sitting on the carriage the while. A mortar was fired a few times, and at each round the angle was changed with considerable facility. Various guns on the field were examined and admired, and a 10½-inch gun was fired at the rate of 8 rounds a minute with striking precision; a similar gun to this at Toulon fires ten 551-lb. shells a minute.

The party were then driven back to St. Chamond, and having bid farewell to our kind host and many of our guides of the day, were driven to the station and proceeded to St. Etienne; but two representatives of the Company were with us, and at St. Etienne Station a dinner was found all ready, having been ordered and provided by the thoughtful and generous hosts of the day. At the close of this repast, Mr. Beardmore remarked how heartily they had all appreciated the kindness and hospitality offered them that day, and how he in particular had been taken by surprise at the vastness and up-to-date character of the great works they had had the privilege of visiting.

Before terminating this notice a few general remarks may be made. Firstly, there are, of course, repairing, joinery, carpentry shops, stores, offices, &c., gas-producers every here and there; but perhaps attention may particularly be drawn to the new steelworks and the iron-foundry. The latter, at P on the plan, is arranged for castings of variable weights and dimensions, from the very smallest up to work attaining 100 tons or more, and to supply all the requirements of the works, even ingot moulds and roll-cylinders. The new steelworks, Q on the plan, are erected to supply the demand of the plate and bar mills that has outgrown the capacity of the old steelworks. There are three furnaces of 20 tons each installed. They are arranged in line in direction of their length and parallel to a long casting-pit served by steam cranes. They are for the production of ingots of less than 5 tons weight, and the first two have been yielding 100 to 120 tons a day.

A word or two about the selection of the material and the system of treatment will scarcely be out of place here. For the manufacture of artillery, for instance, which is entirely executed at St. Chamond, from casting the ingots onwards, only pig made by the Company is employed. The blast-furnaces are at Givors and Boucau. At the former, magnetic ore from their private mines in Sardinia is used,

the 1990s, the number of people in the world who are illiterate has increased from 1.2 billion to 1.5 billion. The number of illiterate people in the world is expected to reach 1.7 billion by the year 2015. The number of illiterate people in the world is expected to reach 1.7 billion by the year 2015. The number of illiterate people in the world is expected to reach 1.7 billion by the year 2015.

| Age Group | 1970 | 1980 | 1990 | 2000 | 2010 | 2020 |
|-----------|------|------|------|------|------|------|
| 0-14 | 20 | 18 | 15 | 12 | 10 | 10 |
| 15-24 | 15 | 14 | 13 | 12 | 11 | 10 |
| 25-34 | 12 | 11 | 10 | 9 | 8 | 7 |
| 35-44 | 10 | 9 | 8 | 7 | 6 | 5 |
| 45-54 | 8 | 7 | 6 | 5 | 4 | 3 |
| 55-64 | 6 | 5 | 4 | 3 | 2 | 1 |
| 65-74 | 4 | 3 | 2 | 1 | 0 | 0 |
| 75+ | 5 | 6 | 7 | 8 | 10 | 20 |

1. *Chlorophyll a* and *Chlorophyll b* were determined by the method of Arar and Collins (1971) using a Shimadzu 1601 UV-Visible Spectrophotometer.

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Figure 1. The effect of the concentration of the *Agrobacterium* suspension on the transformation efficiency of *Agrobacterium* strains. The number of transformed cells was determined by the number of colonies obtained on the selective medium. The results are the mean of three independent experiments. Error bars represent standard deviation.

| Trial | Control (n = 10) | MCI (n = 10) | AD (n = 10) |
|-------|------------------|--------------|-------------|
| 1 | 95 | 85 | 75 |
| 2 | 90 | 80 | 70 |
| 3 | 85 | 75 | 65 |
| 4 | 80 | 70 | 60 |
| 5 | 85 | 75 | 65 |

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| Class of Steel. | Tensile Strength. | Elastic Limit. | Elongation. |
|---|-------------------|-----------------|-------------|
| | kg. per sq. mm. | kg. per sq. mm. | Per Cent. |
| Tire for locomotives | 63.5 | ... | 22.5 |
| Tire for railway car | 52.0 | ... | 27.0 |
| Tire for tramway car | 76.1 | ... | 18.0 |
| Boiler plate, 1 inch thick | 41.8 | ... | 27.0 |
| Extra mild plate, 0.669 inch thick | 40.4 | ... | 31.5 |
| Ordinary mild steel | 40.0 | 26.8 | 29.0* |
| Extra mild steel | 36.9 | 21.7 | 39.0* |
| Mild for naval armaments | 48.6 | 25.9 | 26.5* |
| Medium hard for artillery | 61.4 | 31.3 | 21.0* |
| Medium hard for artillery | 65.6 | 33.8 | 20.0* |
| Chrome steel for shells | 80.2 | 48.0 | 19.0* |
| St. Chamond special | 70.9 | 48.0 | 19.5* |
| Gun steel | 70.0 | 45.0 | 18.0* |
| Nickel steel, 20 to 25 per cent. N ₁ | 73.5 | 36.7 | 64.0* |

There was tested armour plate and sheet of all dimensions, ranging in thickness from 0.315 inch to 10.23 inch. One plate weighing 116 cwts. of St. Chamond special steel, and 10 inches thick, although indented, had resisted six rounds of a 95 lbs. projectile fired from a 5.9-inch gun at speeds varying from 2034 to 2208 feet. Another plate of the same material, $6\frac{5}{16}$ inch thick, and weighing $42\frac{1}{2}$ cwts., had shattered similar projectiles fired from the same gun at successive speeds of 1716, 1800, and 1866 feet; whilst at the other end of the scale the 0.315-inch sheet for screens had resisted the regulation $\frac{1}{2}$ -oz. shot with an impact velocity of 1696 feet.

The display of ordnance on Darmancier and Dalzon system was strong and comprehensive—sea and land guns, cannons, howitzers, mortars, carriages, limbers, and mountings of many patterns, shell of all sizes and kinds, ammunition, and all appurtenances—making a bewildering show from which it would be useless to select an example.

Perhaps, however, the most striking exhibits were the armoured turrets and towers with equipments. One for a rapid-firing 14 calibre $4\frac{1}{2}$ -inch disappearing howitzer was protected with an outer ring consisting of two curved plates of tempered cast iron fixed over the concrete base, and with an inner cylinder of $4\frac{1}{2}$ -inch armour plate, 8 feet 6 inches in diameter, and was covered by a slightly spherical dome of $5\frac{9}{16}$ -inch plate. Another turret, for two 12-inch 40-calibre coast defence guns, revolved on a central pivot; the fixed point 4 feet 10 $\frac{1}{2}$ feet high, 11 inches thick at the top, and 17 $\frac{3}{4}$ inches thick at the bottom, was of curved plates of cast iron, and formed a ring 37 $\frac{3}{4}$ inches in diameter. The moving body of the tower was of $\frac{3}{4}$ -inch plate, and

* Test pieces 0.5725 inch diameter, 3.94 inches long.

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are manipulated under a hammer of 40 tons weight, admirably provided with cranes of 50 and 60 tons lifting powers, and capacious furnaces. They have still three Siemens crucible furnaces, and make several special qualities of tool-steel, such as tungsten and chrome, besides pure carbon steels of various tempers. They also make rods for gun-barrels, cast-steel anvils, springs for railway work (both spiral and laminated), railway and tramway tires, and there is a special department for the manufacture of air-reservoirs for torpedoes.

It will be seen by the above short sketch of the various products turned out by the Société de Firminy how admirably they have recovered from the crisis which occurred in 1880, when they were brought face to face with an entirely new condition of things which suddenly cut off their trade in steel rails, for which the whole works had been specially planned. That they were able to tide over those difficult times and to find themselves once more carried on on a wave of prosperity was due largely to the daring and pertinacity of their far-seeing director, Mr. Hugot, under whose able direction the works were remodelled to suit the changed conditions of their trade. They have a very fine exhibit at Paris of all their principal manufactures.

The party lunched with Mr. Hugot at his house, situated only 200 yards from the works in a pleasant garden with picturesque views of the hills which surround Firminy, and were driven in his carriage to the Unieux Works. There Mr. Brustlein, the managing director, showed the party over the works. They saw the forging of gun-barrel rods under old-fashioned helve-hammers, and in another part of the works a 6000-ton press doing its quiet work on a 40-ton ingot, and served by great travelling cranes spanning the shop from side to side and running right over the top of the press. These are capable of lifting and carrying weights of 60 or 70 tons. The party was delighted with the warm welcome they received, and fully appreciated the kindness with which those they met put themselves to much inconvenience to show them more than ordinary hospitality.

EXCURSION TO ST. DENIS.

Sir William Roberts-Austen, the President, Mr. Snelus, Vice-President, Mr. Bennett Brough, Secretary, and about sixty members of the Institute, accompanied by a fair sprinkling of ladies, assembled on Friday, September 22, at the Paris offices of the Compagnie Française des Métaux in the Rue Volnay, to visit the works of that huge concern at St. Denis. They were taken in motor and horse cabs and in

THE

REPORT OF THE

COMMISSIONER OF THE GENERAL LAND OFFICE

FOR THE YEAR 1890.

PUBLISHED BY ORDER OF THE SECRETARY OF THE INTERIOR.

WASHINGTON: GOVERNMENT PRINTING OFFICE, 1891.

7-5634

Institute of Public Health in Edinburgh in 1893, and delivered an address; and in connection with the last meeting in Edinburgh of the British Association he acted as local secretary. During the summer and autumn of 1879 he undertook an extensive series of observations and experiments with a view of determining the diurnal variation in the amount of carbon dioxide in the air, the results of which were communicated in a paper to the Royal Society, and have since been accepted as a standard of reference on the Continent as well as in this country. In 1889 the Council of King's College, London, elected Professor Armstrong to the Fellowship of the College. He was an examiner for science degrees in the Departments of Engineering, Public Health, and Agriculture in the University of Edinburgh, hon. president of the East of Scotland Engineering Association, a member of the Institution of Civil Engineers, and a Fellow of the Royal Society of Edinburgh. He was elected a member of the Iron and Steel Institute in 1889, and acted as local Honorary Secretary in connection with the Institute's meeting in Edinburgh in 1888.

JOHN HARRIS EDGE died in October 1900 at Shifnal, Shropshire, at the age of sixty-eight. He was the senior partner in the well-known firm of Edge & Sons of the Coalport Works of Shifnal, manufacturers of wire ropes, chains, brick and tile machinery. He was the grandson of the late Mr. Benjamin Edge, who founded the business about the year 1800, and invented the flat-link wood-keyed chain that superseded hemp ropes for winding purposes in pits before wire ropes were adopted. He was elected a member of the Iron and Steel Institute in 1880.

WILLIAM FLETCHER, of Brigham Hill, Cockermouth, whose death occurred on August 6, 1900, was a prominent man in Cumberland. Born in 1831, he was the third son of Mr. J. W. Fletcher, of Tarn Bank, a member of the Society of Friends, and representative of an old Cumberland family. When quite a young man he took part in local public affairs, and being interested in the coal trade, he saw the importance of improving the railway facilities of the district. He was an active promoter of the Cockermouth, Keswick, and Penrith Railway, of which he was one of the first directors, and of the Cleator and Workington Junction Railway, of which he was chairman; and he helped forward the transfer of the Cockermouth and Workington Railway to the London and North-Western Company. He was at one time managing director of the West Cumberland Iron and Steel Company, and latterly of the

department of the firm of Ransomes, Sims, & Jefferies, Limited, Ipswich. He was born in 1840 at Great Barford, Bedfordshire, and in 1856 entered the Orwell Works, Ipswich, as an articled pupil. In 1866 he married a daughter of the late Mr. James Allen Ransome, a member of the firm, and was taken into partnership, the business then existing under the title of Ransomes, Sims, & Head. In 1884, when it was converted into a limited liability company, Mr Jefferies became a managing director. In 1882 he was elected one of six representatives of the Burgesses of Ipswich on the Dock Commission, and in September of the same year he was chosen a member of the Committee of Management. He took the greatest interest in the improvement of the port, and was a most regular attendant at the meetings in connection therewith. On the Ipswich Chamber of Commerce and Shipping being formed in 1884, he succeeded Mr. Edward Packard, who was the first chairman, and in 1900 he was re-elected to that position. He was also that year's chairman of the Agricultural Engineers' Association, a member of the Institute of Mechanical Engineers, and a Justice of the Peace for the borough. He was elected a member of the Iron and Steel Institute in 1879.

JAMES JONES, of Brookland, Swansea, died on November 16, 1899, in his sixty-third year. He was High Sheriff of Cardiganshire, a Justice of the Peace for Cardiganshire and Glamorganshire, and an ex-Mayor of Swansea. He officially attended Bristol in connection with the visit to that city of Her Majesty the Queen the day before his death. Feeling somewhat unwell, he telegraphed for his son, Mr. R. W. Jones, who joined him, and they left Bristol for Swansea. He died during the journey. He was very popular with all classes. Amiable and generous, he was welcomed everywhere. As Mayor of Swansea he dispensed lavish hospitality, and for many years he played a prominent part in the municipal government of Swansea. He was born at Aberystwyth in 1837, but came to Swansea somewhat early in life, and entered the service of Messrs. Philips & Son, wholesale grocers, Castle Square, and was permanently engaged as a traveller. About twelve years after he started business on his own account. He was remarkably successful. He built up a great business, and retired from it several years ago a very wealthy man. He took an active interest in friendly society work. He was patron of the Loyal James Jones Lodge (Independent Order of Foresters, Manchester Union), and very frequently he paid the subscriptions of large numbers of members, in his own as well as in other lodges. He was a member of

for the production of a brand of that all-mine pig iron which years ago made the iron industry of South Staffordshire famous. The dismantling is due to the fact that the furnaces have become obsolete, while the colliery, like so many more in the district, is waterlogged. Mr. Round was the third son of Mr. John Round, of Daisy Bank, near Coseley. He was born on February 2, 1836, and was educated at Harrow School. Afterwards he joined his brothers at Tividale in working the Hange Furnaces and Collieries. In 1888 he formed, with four friends, a syndicate to acquire and work Rixon's blast-furnaces at Wellingborough, now known as the Wellingborough Iron Company, Limited, of which he was managing director until his death. He was a director and vice-chairman of the County of Stafford Bank. He was an original member of the Iron and Steel Institute.

WILLIAM RYLAND died on October 11, 1900, at his residence, Rye Lodge, Nether Edge, Sheffield. He was principally connected with Ryland's Electro-plating Company, Limited. He was elected a member of the Iron and Steel Institute in 1890.

HERBERT SARTORIS died at Ostend on August 30, 1900. Born on November 12, 1845, he was educated at Eton, and after leaving there served his time with Messrs. Stevenson & Son, engineers, of Newcastle-on-Tyne. After his term of service he went to the Continent, and had a great deal to do with the construction of railways in the North of France and Belgium. After spending about ten years on the Continent he returned to England for a short time, and after that he went to Hungary, Egypt, and Brazil on various railway constructions. He was engaged at Islip Furnaces on his return, and shortly after that he and Mr. F. W. Preston took over the ironstone pits of Messrs. Wallis & Manners, near Kettering, in 1876. The present furnaces on the Rockingham Road were begun and blown-in in 1878. He was managing director with Mr. Preston since the commencement of the works. He was elected a member of the Iron and Steel Institute in 1877.

CHARLES TYLDEN-WRIGHT, who died on August 8, 1900, at his residence, Mapperley Hall, Nottingham, at the age of sixty-eight, after a few days' illness, was one of the leading authorities on coal-mining in Great Britain. After a course of study at the Royal School of Mines and at Freiberg and Liège, he occupied from 1858 to 1886 the position of managing director of Shireoakes Colliery. From 1886 to 1890 he

ADDITIONS TO THE LIBRARY

DURING THE SECOND HALF OF 1900.

| Title. | By whom Presented. |
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| "Lloyd's Register of British and Foreign Shipping." Vols. i. and ii., with Rules and Regulations. London. 1900. | The Secretary. |
| "British Corporation for the Survey and Registry of Shipping." Glasgow. 1900. | The Secretary. |
| "Report upon the Seventh International Congress of Navigation held at Brussels, July 1898." Washington. 1900. | The Department of State (Washington). |
| "Statistics, History, and Resources of New South Wales." London. 1900. | The Agent-General for N.S.W. |
| "Steel, and its Use in Cycle Construction." By D. Flather. 1900. | The Author. |
| "Chief Engineers' Report of the Engine, Boiler, and Employers' Liability Insurance Co., Ltd., for 1899." Manchester. 1900. | The Company. |
| "On Blast-Furnace Burdens." By Walter Macfarlane. Brierley Hill. 1900. | The Author. |
| "Mines and Quarries, General Report and Statistics for 1899." Part II. Labour. London. 1900. | The Under-Secretary of State. |
| "Reports for the North Wales, &c., District to H.M. Secretary of State for the Home Department." London. 1900. | C. Le Neve Foster. |
| "Les Embarcadères 'Cantilever' de la Côte Cantabre." By A. Dory. | The Author. |
| "The Creation and Development of the Steam Engine." With Diagram. By Henry W. Pearson. 1900. | The Author. |
| "Mathematical Drawing and Measuring Instruments." By William F. Stanley. London. 1900. | The Author. |
| "Die Bedeutung der Phasenlehre." By H. W. Bakhuis-Roozeboom. Leipzig. 1900. | The Author. |

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| "Moteurs à Gaz de Hauts-Fourneaux, Système Delamare - Deboutteville et Cockerill." Paris. 1900. | A. Greiner. |
| "Utilisation Directe des Gaz de Hauts-Fourneaux pour la Production de la Force Motrice." Par H. Hubert. St. Etienne. 1900. | A. Greiner. |
| "Capital and Labour in Coal-Mining." By J. B. Simpson. Newcastle - upon - Tyne. 1900. | The Author. |
| "La Tour de Trois Metres." By G. Eiffel. Paris. 2 vols. 1900. | The Author. |
| "Report of the Department of Mines for the Year 1899." Perth. 1900. | The Under-Secretary for Mines, Perth. |
| "The Mineral Wealth of Western Australia." By A. G. Maitland. Perth. 1900. | The Under-Secretary for Mines, Perth. |
| "Compagnie des Forges et Aciéries de la Marine et des Chemin de Fer. Usines de la Compagnie, principaux Ateliers, quelques Spécimens des Fabrications." St. Chamond. 1900. | A. de Montgolfier. |
| "Grundzüge der Siderologie." By Hanns Freiherr von Jüptner. Leipzig. 1900. | The Publishers. |
| "Travaux Scientifiques exécutés à la tour de trois cents mètres." By G. Eiffel. Paris. 1900. | The Author. |

INSTITUTIONS.

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Institution of Electrical Engineers.
Institution of Mechanical Engineers.
Institution of Mining and Metallurgy.
Institution of Naval Architects.

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| Age Group | 1997 | 2000 | 2003 |
|-----------|------|------|------|
| 18-29 | ~85% | ~88% | ~90% |
| 30-49 | ~75% | ~78% | ~80% |
| 50-69 | ~65% | ~68% | ~70% |
| 70+ | ~55% | ~58% | ~60% |

10-11-68

1. The first group of respondents (10%) was made up of 100% females, 100% of whom were married. The mean age was 37.5 years, with a range of 25 to 55 years. The mean number of children was 2.5, with a range of 1 to 4 children. The mean number of years of education was 12.5, with a range of 10 to 16 years. The mean number of years of employment was 10.5, with a range of 5 to 20 years. The mean number of years of experience in the current position was 5.5, with a range of 2 to 10 years. The mean number of years of experience in the current position was 5.5, with a range of 2 to 10 years.

1. The first group of authors (see Table 1) has been concerned with the effects of the type of stimulus on the response. The stimulus has been varied in terms of the number of stimuli, the type of stimulus, the duration of the stimulus, and the intensity of the stimulus. The response has been varied in terms of the type of response, the duration of the response, and the intensity of the response. The results of these studies have been mixed, with some studies showing a positive relationship between stimulus and response, and others showing no relationship.

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WILLIAM A. GUNDEL

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1. *Journal of the American Medical Association*, 1997; 277: 1033-1038.

United States.

Alabama Industrial and Scientific Society.
American Association for the Advancement of Science.
American Institute of Mining Engineers.
American Iron and Steel Association.
American Society of Civil Engineers.
American Society of Mechanical Engineers.
Department of Labour.
Engineers' Society of Western Pennsylvania.
Franklin Institute.
New York Academy of Sciences.
Ordnance Office, War Department.
School of Mines, Columbia College, New York.
Smithsonian Institute.
United States Geological Survey.

Austria.

K.k. geologische Reichsanstalt.
Oesterr. Ingenieur- und Architekten-Verein.

Belgium.

Association des Ingénieurs sortis de l'Ecole des Mines de Liège.
Ministère de l'Intérieur.

France.

Comité des Forges.
"Revue Maritime." Ministère de la Marine.
Société d'Encouragement pour l'Industrie Nationale.
Société de l'Industrie Minérale.
Société des Anciens Élèves des Écoles Nationales d'Arts et Métiers.
Société des Ingénieurs Civils.
Société Scientifique Industrielle de Marseille.

Denmark.

Tekniske Foreningen.

Germany.

Königliche Bergakademie in Freiberg.
Königliche Technische Versuchsanstalt.
Verein Deutscher Eisenhüttenleute. (Journal "Stahl und Eisen.")
Verein Deutscher Ingenieure.

Italy.

Reale Accademia dei Lincei.

Sweden.

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- "American Machinist."
- "American Manufacturer."
- "Bradstreet's."
- "Cassier's Magazine."
- "Engineering and Mining Journal."
- "Engineering Magazine."
- "Engineering News."
- "Iron Age."
- "Iron Trade Review."
- "Letter of the Anthracite Coal Operators' Association."
- "Metallographist."
- "Mines and Minerals."
- "Railroad Gazette."
- "Report of Proceedings of the Master Car Builders' Association."
- "Tin and Terne."

Austria.

- "Oesterr. Zeitschrift für Berg- und Hüttenwesen."

Belgium.

- "Bulletin de l'Union des Charbonnages de Liège."
- "Moniteur des Intérêts Matériels."
- "Revue Universelle des Mines."

France.

- "Annales des Mines."
- "L'Echo des Mines."
- "Le Génie Civil."
- "Le Mois Scientifique et Industriel."
- "Portefeuille Économique."

Germany.

- "Annalen für Gewerbe und Bauwesen."
- "Chemiker Zeitung."
- "Glückauf."
- "Verein Deutscher Eisen und Stahl Industrieller."
- "Zeitschrift für das Berg-, Hütten- und Salinenwesen im preussischen Staate."
- "Zeitschrift für praktische Geologie."
- "Zeitschrift für Werkzeugmaschinen und Werkzeuge."

Italy.

- "L'Industria."
- "Rassegna Mineraria."

Spain.

- "España."
- "Revista Minera."

Sweden.

- "Teknisk Tidskrift."

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IRON ORES.

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I.—OCCURRENCE AND COMPOSITION.

The Genesis of Ore Deposits.—Several lengthy papers on the origin of ore deposits have recently been published. Charles R. Keyes * deals with the origin and classification of ore deposits. He considers the basis of classification and presents a scheme.

S. F. Emmons † discusses the secondary enrichment of ore deposits, giving a statement of his belief and arguments in its favour.

In a course of four Cantor Lectures delivered before the Society of Arts by Bennett H. Brough, ‡ on the nature and yield of metalliferous deposits, the author incidentally dealt with the classification of ore deposits.

The simplest classification divides them into (1) beds, (2) veins, and (3) masses. This classification has proved well adapted for practical use. The more elaborate systems of classification that have from time to time been proposed are fully discussed, the classifications dealt with being those of Agricola (1555), Burat (1855), B. von Cotta (1853), Grimm (1869), J. A. Phillips (1884), A. von Groddeck (1878), F. Posepny (1880), Sir A. Geikie (1882), H. S. Monroe (1892), H. F. Kemp (1892), H. Louis (1896), H. Hoefer (1897), and G. Gürich (1899). The last-named investigator uses the mode of concentration

* *Transactions of the American Institute of Mining Engineers*, February 1900.

† *Ibid.*

‡ *Journal of the Society of Arts*, vol. xlviii. pp. 673-687.

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and Steel Institute in 1882, has been investigated by M. Vacek,* who gives a section of the mountain showing the complicated character of its geological structure. The mountain is situated at the contact of Triassic rocks and Palæozoic and crystalline rocks. It forms a cone 5000 feet in height, and is composed of no less than four series of beds stratigraphically independent—namely, at the base (1) gneiss, the oldest rock of the whole district; (2) Lower Devonian beds deposited unconformably above the gneiss; (3) the ironstone formation; and lastly (4) the Werfener beds.

An account is published † of the iron industry of Styria in the fifteenth and sixteenth centuries. Special mention is made of the influence exerted by Peter Pögel and his son, in the latter half of the fifteenth and the first half of the sixteenth centuries, and of the Am Thörl iron-works. The rise and subsequent decadence of the Styrian industry of that period is shown to have been closely connected with the fortunes of the Pögel family.

Iron Ore in Bosnia.—The iron ore district of Vares, in Bosnia, has been described in a work of 94 pages by F. Katzer.‡ Illustrated by a coloured geological map and by 22 illustrations in the text, it deals exhaustively with the geological structure of the district, the iron ore deposits, and the deposits of manganese and sulphide ores. The iron ore deposits have long been known. Indeed, they are believed to have been worked in pre-Roman times. The beds are of Triassic age and occur in association with limestone. The deposits are described as being among the richest in Europe.

Iron Ore in France.—F. Villain recently read before a technical society at Nancy an important paper on the iron ore deposits of Meurthe-et-Moselle. It is published in full in the *Revue Industrielle de l'Est* of July 1, accompanied by a map of the mines of the Briey basin, a contour map of the Briey deposit, various sections of the ore-bearing beds, section of the Briey basin between Sancy and Eton and between Mercy and Avril, and a geological sketch map of the East of France.

Iron Ore in Lorraine.—A map of the minette ore district of Lorraine and Luxemburg, together with some illustrations and a

* *Jahrbuch der k.k. geologischen Reichsanstalt*, vol. 1. pp. 23-32.

† *Oesterr.-Ung. Montan- und Met. Zeitung*, 1900, No. 14; *Stahl und Eisen*, vol. xx. pp. 614-615.

‡ *Berg- und Hüttenmännisches Jahrbuch der k.k. Bergakademien*, vol. xlviii. pp. 99-189.

Figure 1. The effect of the concentration of the *Agrobacterium* suspension on the transformation efficiency of *Agrobacterium* strains. The number of transformed cells was determined by the number of colonies obtained on the selective medium. The results are the mean of three independent experiments. Error bars represent standard deviation.

SECRET

1. The first step is to identify the problem. This involves understanding the current situation and what needs to be changed.

2. The second step is to set goals. These should be specific, measurable, achievable, relevant, and time-bound.

3. The third step is to develop a plan. This involves determining the steps that need to be taken to achieve the goals.

4. The fourth step is to implement the plan. This involves putting the plan into action and monitoring progress.

5. The fifth step is to evaluate the results. This involves assessing whether the goals have been achieved and what lessons can be learned.

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1. *Journal of the American Medical Association*, 1990; 263: 1033-1036.

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Iron Ore in Russia.—In a paper read at the International Mining Congress at Paris, Szymanowsky * described the Krivoi-Rog ore deposits, and the present conditions of the metallurgical industry in Southern Russia. Plans of the deposits are given and their geology is discussed. It is considered that the mineral wealth of Krivoi-Rog constitutes the foundation of the iron industry in South Russia, the other productive patches of the so-called crystalline schists (of which the Krivoi-Rog basin forms part) containing only very small quantities of iron ore. The Krivoi-Rog reserves, estimated from trustworthy data, are sufficient to maintain this industry for thirty years. Although the available quantity of Kertch ore is enormous, it cannot be used in works far removed from the deposit; and even at those near Kertch the local ore can scarcely be employed in larger proportions than 30 to 40 per cent. of the charge.

Iron Ore in Spain.—An account has been published † of a company which has been formed to work the Carreño iron ore mines in Asturias. There are six beds of hæmatite of Devonian age, the amount of ore available being estimated at 60,000,000 tons. Typical analyses of the ore yielded 50·89, 49·88, and 47·59 per cent. of iron.

Swedish Iron Ores.—The following are analyses of the Swedish iron ores exhibited at the Paris Exhibition : ‡—

| Ore from | Iron. | Phosphorus. | Sulphur. |
|------------------|-----------|-------------|-----------|
| | Per Cent. | Per Cent. | Per Cent. |
| Johannesberg . . | 51·4 | 0·002 | 0·030 |
| Burångsberg . . | 55·5 | 0·005 | 0·025 |
| Bispberg . . . | 68·1 | 0·003 | 0·003 |
| Stripsa . . . | 52·0 | 0·008 | 0·003 |

Iron Ore Deposits in Northern Sweden.—In 1899 two expeditions were sent out officially for the purpose of examining the iron ore deposits of the province of Norbotten, and a report of their work has recently been published by F. Svenonius§ and W. Petersson. Altogether forty-four different ore deposits were examined. Most of them occur in syenite, syenite porphyry,

* *Bulletin de la Société de l'Industrie Minérale* (advance proof).

† *Revista Minera*, vol. li. p. 465.

‡ *Stahl und Eisen*, vol. xx. p. 636.

§ *Jernkontorets Annaler*, 1900, pp. 215-368.

and calc spar; and while somewhat richer in iron than the black ore, is poorer in phosphorus and calcium carbonate. Titanic acid and sulphur are low in both cases.

This Svappavara deposit consists of a system of elongated lenses, surrounded by syenitic granulite, striking north and south and dipping sharply to the east.

A newly opened up ore deposit is that of Leveäniemi. It is of large extent, but throughout its whole length is covered with from 10 to 48 feet of over-burden. Diamond drills have shown large deposits of hæmatite and magnetite. The iron contents varies from 60·73 to 70·39 per cent., that of phosphorus from 0·008 to 2·35, and that of sulphur from 0·03 to 0·05. An average sample contains 0·07 per cent. of titanic acid. The length of the deposit is estimated at over 3900 feet, and its width at from 500 to 1640 feet.

To the south-east and north-west of the village of Svappavara lie other deposits. One of these, that of Mertainen, is of very considerable extent. Thirty-seven analyses of the separated ore showed from 41·28 to 69·48 per cent. of iron, and from 0·002 to 0·277 per cent. of phosphorus. About five miles south of the above field is that of Painirova. The conditions are much the same in both cases, except that in the latter there are very considerable local enrichments of apatite, whereas in the Mertainen deposit this mineral was of minor importance. In a number of average samples the iron contents was found to vary from 51·44 to 68·31, and that of phosphorus from 0·023 to 1·587.

Owing to a thick over-burden of earth, it was not possible to thoroughly investigate this deposit. The ores may be considered as consisting of a fine-grained magnetite, which in places is very porous, probably due to one or other of the mineral constituents of the ore having been dissolved out. The percentage of phosphorus is low in the north-western portion of the district, varying from 0·014 per cent. to 0·061, with an iron percentage of from 60·69 to 69·31 in five samples examined. In the south-western and eastern portions of this field the phosphorus contents is, on the other hand, very high. It varies there from 0·244 to 1·380. The percentage of iron varies greatly, but does not fall below 50. The apatite is in part very coarse grained and unevenly distributed. The quantity of available ore is not believed to be very great.

The Ylipäsnjaska and Nokutusvara deposits are next briefly referred to, but little definite being known about them yet. The Tuolluvara deposit is about three miles to the east of that of Luossavara. Magnetic

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deposits of Northern Sweden is discussed by O. Vogel,* and various translations of it have appeared.†

Iron Ore in Switzerland.—A brief reference is made to the iron ores of the Bernese Oberland. These were worked down to the end of the eighteenth century. The ore is found in beds of about 1 yard to 4 yards in thickness. They formerly served blast-furnaces at Mühlthal and Grund, near Innertkirchen. The fuel used was charcoal, and the woods being destroyed, the furnaces had to stop. The ore averages about 50 per cent. of iron.‡

Iron Ore in New South Wales.—W. S. Dun§ has published a list of papers and reports dealing with the economic geology of New South Wales. The list includes, under a separate heading, the titles of the more important papers dealing with the occurrence of iron ore in New South Wales.

J. B. Jaquet|| gives some notes on the iron ore deposits in the Carcour district, Bathurst county, New South Wales. The ore is hæmatite, and analyses show as follows :—

| Metallic Iron. | Silica. | Phosphoric Acid. |
|----------------|---------|------------------|
| 55·80 | 7·45 | 0·396 |
| 57·54 | 5·90 | 0·166 |
| 55·80 | 6·95 | 0·063 |

Iron Ore in New Zealand.—H. P. Washbourn¶ shortly describes the Parapara iron ore deposit in New Zealand. It is situated on Golden Bay, five miles south of Collingwood. The ore is limonite, containing 53·38 per cent. of iron, and is free from phosphorus. It is found in a limestone basin, some four miles long by three broad, dipping to the north. The width of ore outcropping on the surface is from 10 to 13 chains, and shows in large masses for several miles southwards or inland. The limestone of the basin is a very pure carbonate of lime; the impurities amount at most to less than 2 per cent. Coal is being worked in a seam 4½ feet in thickness at the northern end of the bay.

* *Stahl und Eisen*, vol. xx. pp. 530-536, 590-592.

† *Iron and Coal Trades Review*, vol. lxi. pp. 78, 123; *Glückauf*, vol. xxxvi. pp. 620-621, 658-660.

‡ *Stahl und Eisen*, vol. xx. p. 500.

§ *Records of the Geological Survey of New South Wales*, vol. vi. pp. 183-357.

|| *Colliery Guardian*, vol. lxxx. p. 553.

¶ *New Zealand Mines Record*, March 1900; *Engineering and Mining Journal*, vol. lxi. p. 588.

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yet been touched. From the three workings in the lower bed the ore obtained shows 56 to 60 per cent. of iron with 0·4 to 0·7 of phosphorus. Other districts are also described and illustrated.

The Crystal Falls Iron-bearing District.—The United States Geological Survey* has published a monograph, covering 512 pages, with 53 plates and 24 illustrations, on the Crystal Falls iron-bearing district of Michigan, by J. M. Clements and H. L. Smyth, with a chapter on the Sturgeon river by W. S. Bayley and an introduction by C. R. Van Hise. The district derives its name from the principal mining town, and the area reported upon connects the Marquette district on the north and the Menominee district on the south. The ore worked is hæmatite and limonite, associated with white and reddish chert. The ore bodies, which dip to the west at varying angles, are concentrated in synclinal troughs. The mining is now for the most part underground, and is carried on in open stopes. The greatest shipment of ore from the area was 586,970 tons in 1892. The district embraced in the report covers 1296 square miles, including the Crystal Falls, Amasa, Felch mountain or Metropolitan and Sturgeon river districts. Of these, the first two produced nearly 325,814 tons of ore in 1898, chiefly non-Bessemer hæmatites and limonites. Geologically the district connects the Marquette and Menominee districts, and consists of Huronian rocks enclosing two archæan patches. The history of the Crystal Falls district is closely parallel to that of the Marquette district, but the number of distinct formations recognised in it is smaller. The ores exist in it in Huronian beds, which lie unconformably above an older series of crystalline schists. Glauconite or some iron carbonate was the original source of the iron, and descending waters were the agents of decomposition, transportation, and precipitation.

Iron Ore in Georgia.—R. H. Couper† notes the increasing importance of the yellow-ochre mines of the Cartersville district in Georgia. The bed is 3 to 8 feet in thickness and about 28 tons of ochre are produced daily.

Iron Ore in Massachusetts.—In a monograph on the geology of Eastern Berkshire, Massachusetts, B. K. Emerson‡ points out that there is not the slightest possibility of finding coal in the district. Much

* *Monographs of the United States Geological Survey*, vol. xxxvi.

† *Engineering and Mining Journal*, vol. lxi. p. 788.

‡ *United States Geological Survey*, Bulletin No. 159.

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Recent Researches on Meteorites.—S. Meunier* gives an account of the meteorite, weighing about 750 lbs., which fell on March 12, 1897, in the Gulf of Finland, making a hole 9 yards in diameter through ice 26 inches in thickness, and burying itself 6 yards deep in the submarine clay. Two pieces of 184 and 48 lbs. were exhibited at the Paris Exhibition. The author describes it as oolitic, composed of chrysolite and pyroxene, with grains of nickel iron, iron sulphide, and chromite. Its specific gravity is 3·54.

According to H. L. Preston,† a meteoric iron, which weighs 6903 grammes, was found in 1896 near Luis Lopez, Socorro Co. It contains numerous nodules of troilite surrounded by zones of schreibersite or of a graphitic substance. The etched surface shows typical octahedral Widmanstätten figures. The structure and chemical composition (analysis I.) of this iron distinguish it from the five other irons (Costilla, Glorieta, El Capitan, Sacramento Mountains, and Oscuro) recently found in the same region in New Mexico.

| | Fe. | Ni. | Co. | Si. | P. | S. | C. | Totals. | Sp. gr. |
|---------|--------|-------|-------|-------|-------|-------|-------|---------|---------|
| I. . . | 91·312 | 8·170 | 0·160 | trace | 0·333 | 0·013 | 0·012 | 100·00 | 7·7 |
| II. . . | 94·734 | 4·620 | 0·180 | ... | 0·442 | 0·015 | 0·009 | 100·00 | 7·5 |

All that is known of the history of the Central Missouri iron is that it was found in the fifties in Central Missouri. About half the mass weighs 12,360 grammes. It is penetrated by numerous fissures filled with a graphite-like substance, and in part by schreibersite. The etched surface is minutely pitted. Analysis gave the result shown under II.

W. E. Hidden ‡ illustrates a piece of meteoric iron found in Hayden Creek, Idaho, by a gold prospector at the bottom of a twelve-foot shaft. With much difficulty he succeeded in breaking it with a 14-lb. sledge.

H. L. Preston§ describes an aërolite from Oakley, Logan County, Kansas, weighing 61 lbs. 10 oz. It contains 14·44 per cent. of iron and nickel in the metallic state and 85·56 per cent. of silicates. It is of the chondritic olivine-enstatite type.

E. Boscá y Casanoves|| describes the meteorite that fell at Quesa, in Valencia, Spain, on August 1, 1898. It weighs 10,670 grammes, and has the fine-grained structure of an ataxite. Its specific gravity is

* *Le Naturaliste*; *American Journal of Science*, vol. x. p. 250.

† *American Journal of Science*, vol. ix. pp. 283-286.

‡ *Ibid.*, vol. ix. pp. 367-368.

§ *Ibid.*, pp. 410-412.

|| *Actas Sociedad Española Hist. Nat.*, 1899, pp. 53-56; *Journal of the Chemical Society*, vol. lxxviii. p. 415.

1. The first part of the paper is devoted to a general discussion of the problem of the origin of life.

2. The second part of the paper is devoted to a detailed discussion of the problem of the origin of life.

3. The third part of the paper is devoted to a detailed discussion of the problem of the origin of life.

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17. The seventeenth part of the paper is devoted to a detailed discussion of the problem of the origin of life.

18. The eighteenth part of the paper is devoted to a detailed discussion of the problem of the origin of life.

Emil W. Cohen * gives some new analyses of the following meteoric irons:—

Salt River, Kentucky.—In structure (octahedral with fine lamellæ) and composition (analysis I.) this resembles the Ballinoo and Tocavita irons. Specific gravity, 7·6648.

Cape of Good Hope.—Analysis II. Specific gravity, 7·8543. This resembles the Kokomo and Iquique irons.

Babb's Mill, Green County, Tennessee.—Analyses III. and IV. are of material from different portions of the mass described by Blake in 1886 under the name Green County. V. is of the Babb's Mill mass, described by Troost in 1845. Although these differ considerably in chemical composition, they probably represent the same fall, since both belong to the rare type of ataxites rich in nickel.

| | Fe. | Ni. | Co. | Cu. | Cr. | C. | S. | P. | Cl. | Totals. |
|----------|-------|-------|------|--------|------|------|--------|-------|--------|---------|
| I. . . | 90·89 | 8·70 | 0·85 | 0·04 | 0·00 | 0·02 | trace | 0·34 | ... | 100·84 |
| II. . . | 82·87 | 15·67 | 0·96 | 0·03 | 0·04 | 0·03 | 0·00 | 0·09 | 0·01 | 99·69 |
| III. . . | 88·41 | 11·09 | 0·66 | undet. | 0·02 | 0·03 | trace? | trace | 0·02 | 100·23 |
| IV. . . | 88·23 | 11·01 | 0·72 | undet. | 0·02 | 0·03 | trace? | trace | 0·01 | 100·02 |
| V. . . | 81·45 | 17·30 | 1·67 | 0·03 | 0·03 | 0·07 | 0·01 | 0·12 | undet. | 100·68 |

Origin of Native Iron.—C. Winkler † suggests that the native iron found in the basalt of Disko Island, West Greenland, may have been formed from iron and nickel carbonyls.

Manganese Ore in France.—F. Klockmann ‡ describes the manganese ore deposits of the French Pyrenees. The deposits are of two types:—1. Those of the Vielle Aure type, which are conformably interstratified between Devonian slates. The ore consists of manganese oxides that pass with increasing depth into silicates (rhodonite and friedelite). 2. Those of the Las Cabesses type, which occur in Upper Devonian grits. The outcrop consists of oxides, but at greater depths masses of pure carbonate occur. In a crude state the ores contain 40 to 42 per cent. of manganese, 1·5 to 2 per cent. of iron, 6 per cent. of lime, 6 to 7 per cent. of silica, and 0·04 to 0·05 per cent. of phosphorus. When calcined, the ores contain 50 to 56 per cent. of manganese.

* *Annalen des k.k. naturhistorischen Hofmuseums zu Wien*, vol. xv. pp. 74–94; *Journal of the Chemical Society*, vol. lxxviii. p. 664.

† *Berichte der königlichen sächsischen Gesellschaft, Mathematisch-physikalische Klasse*, vol. lli. pp. 9–16; *Journal of the Chemical Society*, vol. lxxviii. p. 598.

‡ *Zeitschrift für praktische Geologie*, 1900, pp. 265–275.

Diagram 1-1 to 1-10

Diagram 1-1 to 1-10 are the first ten diagrams of the series. They are arranged in a sequence of ten pages. Each diagram is a simple line drawing of a person's head and shoulders, facing forward. The person has short, dark hair and is wearing a dark jacket over a light-colored shirt. The background is plain white. The diagrams are arranged in a grid-like fashion, with ten diagrams per page. The first diagram is at the top left, and the last diagram is at the bottom right. The diagrams are numbered 1-1 through 1-10. The first diagram is labeled '1-1' and the last diagram is labeled '1-10'. The diagrams are arranged in a sequence of ten pages, with ten diagrams per page. The first diagram is at the top left, and the last diagram is at the bottom right. The diagrams are numbered 1-1 through 1-10. The first diagram is labeled '1-1' and the last diagram is labeled '1-10'.

Diagram 1-11 to 1-20 and Diagram 1-21

Diagram 1-11 to 1-20 and Diagram 1-21 are the next ten diagrams of the series. They are arranged in a sequence of two pages. Each diagram is a simple line drawing of a person's head and shoulders, facing forward. The person has short, dark hair and is wearing a dark jacket over a light-colored shirt. The background is plain white. The diagrams are arranged in a grid-like fashion, with ten diagrams per page. The first diagram is at the top left, and the last diagram is at the bottom right. The diagrams are numbered 1-11 through 1-21. The first diagram is labeled '1-11' and the last diagram is labeled '1-21'.

Diagram 1-22 to 1-30 and Diagram 1-31

Diagram 1-22 to 1-30 and Diagram 1-31 are the next ten diagrams of the series. They are arranged in a sequence of two pages. Each diagram is a simple line drawing of a person's head and shoulders, facing forward. The person has short, dark hair and is wearing a dark jacket over a light-colored shirt. The background is plain white. The diagrams are arranged in a grid-like fashion, with ten diagrams per page. The first diagram is at the top left, and the last diagram is at the bottom right. The diagrams are numbered 1-22 through 1-31. The first diagram is labeled '1-22' and the last diagram is labeled '1-31'.

Diagram 1-32 to 1-40 and Diagram 1-41

Diagram 1-42 to 1-50 and Diagram 1-51

Diagram 1-42 to 1-50 and Diagram 1-51 are the next ten diagrams of the series. They are arranged in a sequence of two pages. Each diagram is a simple line drawing of a person's head and shoulders, facing forward. The person has short, dark hair and is wearing a dark jacket over a light-colored shirt. The background is plain white. The diagrams are arranged in a grid-like fashion, with ten diagrams per page. The first diagram is at the top left, and the last diagram is at the bottom right. The diagrams are numbered 1-42 through 1-51. The first diagram is labeled '1-42' and the last diagram is labeled '1-51'.

Diagram 1-52 to 1-60 and Diagram 1-61

Diagram 1-52 to 1-60 and Diagram 1-61 are the next ten diagrams of the series. They are arranged in a sequence of two pages. Each diagram is a simple line drawing of a person's head and shoulders, facing forward. The person has short, dark hair and is wearing a dark jacket over a light-colored shirt. The background is plain white. The diagrams are arranged in a grid-like fashion, with ten diagrams per page. The first diagram is at the top left, and the last diagram is at the bottom right. The diagrams are numbered 1-52 through 1-61. The first diagram is labeled '1-52' and the last diagram is labeled '1-61'.

loading ore into waggons. The machine is the first one built, and it has worked well, except that parts require strengthening. It consists of a kind of bucket elevator, like that used in a dredge, mounted on a truck with a pivoted adjustment, the angle of which can be altered. It excavates and raises the ore so that it falls into the waggons.

Construction of a Dam.—W. Oppl* describes the construction of a dam to keep back water issuing from a long cross-cut in connection with the Przibram mines in Bohemia. In its construction 48 tons of Portland cement, 26 tons of slag sand, 5000 slag bricks, and other material was employed. The total cost of the materials was about £31, and the wages paid amounted to about £83. Details are given as to how a spot was selected at which to construct the dam, and then of the dam itself. The central portion of this consisted of a mixture of one part of Königshof Portland cement and two parts of granulated iron blast-furnace sand and four parts of quartz. This was prepared quite close to the dam. The great care taken in the construction of the dam, and the difficulties that had to be overcome in its construction, caused this to require about ten weeks for its completion. It had to withstand great pressure, and this was subsequently found by a manometer to have reached thirty-one atmospheres, at which the pressure has remained constant since August 1898, the dam having shown no signs of yielding. It was, however, anticipated that the dam would have to withstand a still higher pressure, estimated at as much as forty-one atmospheres. The erection of this dam has meant a saving of about 40 tons of coal a month for pumping purposes.

Iron Ore Mining in Belle Island.—R. E. Chambers † gives some notes on the iron ore mining at the Wabana mine on Belle Island, with numerous plans and illustrations, especially of the haulage, storage, and shipping plant.

Lake Superior Mining.—According to W. Fawcett,‡ activity in the Lake Superior iron ore district has greatly increased this year, and a recent estimate places the ore in sight at 400,000,000 tons. At the Riverton mines, on the Menominee Range, the Iron river, a stream of considerable size, has been diverted.

* *Oesterreichische Zeitschrift für Berg- und Hüttenwesen*, vol. xlviii. pp. 33-36, with three illustrations.

† *Journal of the Canadian Mining Institute*, vol. iii. pp. 130-132, with six plates.

‡ *American Manufacturer*, vol. lxvi. pp. 274-275.

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by Frahm.* The account is one of very considerable length, and generally is a most important addition to the literature of this subject.

In a series of articles, the questions connected with the transport and storage of iron ore and coal are dealt with very fully by M. Buhle.† The author gives a large number of illustrations descriptive of the methods in use for the above purposes at a large number of different places.

Aumund‡ describes the Hunt transporters for iron ore erected at several European works.

A. Hausing§ discusses the relative value of wire ropeways. In the case in question, the ore had to be brought down to a washing plant from a mine nearly 1100 feet higher up. The old system of waggons, cars, or sledges did not succeed in keeping the washing plant fully employed, and besides was very costly. A new method had therefore to be adopted. The question considered was whether this should take the form of an incline or of a wire ropeway. The cost of the former was less than two-fifths that of the latter, and it was consequently erected. It worked very well in summer, but cost far too much to keep open in winter, as six feet or more of snow often settled upon it. A wire ropeway was subsequently erected elsewhere at these mines. This was more expensive to build, but requires less labour, and is generally much cheaper to work, besides not suffering from winter snow.

A. Dory|| describes and illustrates the cantilever loading stages of Onton, Dicidio, Sonavia, Castro-Allen, Castro-Urdiales, and Setares on the northern coast of Spain, in Biscay, Guipuzcoa, and Santander. That at Onton is the largest, being 328 feet in length, with an overhang of 213½ feet, and a height of 55 feet above sea-level.

W. Fawcett¶ illustrates and describes the three Hulett ore unloaders at Conneaut, Ohio, on Lake Erie, one of which was in work last year, and the two new machines, which are practically double machines. In the first machine a clam-shell bucket, holding 10 tons, is carried by a leg at the end of a pivoted beam, and the leg

* *Stahl und Eisen*, vol. xx. pp. 513-522, 597-603, 653-661, 698-701, 750-752, and 798-802, with 70 illustrations.

† *Zeitschrift des Vereines deutscher Ingenieure*, vol. xxxiv. pp. 725-732, 1093-1098, with 220 illustrations.

‡ *Stahl und Eisen*, vol. xx. pp. 825-835; *Colliery Guardian*, vol. lxxx. pp. 475-478.

§ *Oesterreichische Zeitschrift für Berg- und Hüttenwesen*, vol. xlviii. p. 412.

|| Pamphlet presented to the Library by the Author.

¶ *Iron Age*, April 5, 1900, pp. 1-5.

pure, and in order to know the size of the grains to which the mineral should be reduced for treatment, it was advisable to examine them with a microscope. In treating ores mixed with pyrites, it was possible to obtain good results by, first of all, partially roasting the ore, so as to eliminate the sulphur, and a large number of minerals, which could only be separated with difficulty by the magnet when dry, could be easily treated when they were held in suspension in water. There is a vast field open for good and useful inventions for the magnetic separation of minerals, and there is also a great deal to be done in utilising the very fine ore obtained by these processes in the blast-furnace without considerably diminishing the production or augmenting the cost of fuel. The only satisfactory solution seems to be to transform the fine ore into compact masses, and it has been proposed to manufacture briquettes by means of a mixture of argillaceous cement; but the result has not been satisfactory any more than the other methods of using hydrated lime and siliceous matters. Trials with a mixture of very fine grains of iron ore and coal had failed, but with certain other bodies containing carbon, such as tar and petroleum or cellulose by-products, some success has been attained by raising the materials to a relatively high temperature and subjecting them to a great pressure. A solid product could only be obtained with very fine grains of mineral, so that in this sense the magnetic preparation gave the best results. These trials were still incomplete, and required to be followed up on a larger scale.

A further paper by Smits also describes the Wetherill process and the Lohmannsfeld plant, erected in the Siegen district for treating a mixed ore containing blende, galena, spathic iron, &c.

The Wetherill process is described by C. Blömeke * in an article on the progress of ore dressing, of which a translation has appeared.†

N. Pellati ‡ describes the mechanical and other appliances used in Sardinia for dressing ores. Magnetic separators are used for limonite, rendered magnetic by roasting.

E. Ferraris§ describes some ore-washing plants in use at the mines of Sardinia. Some "swinging sieves" are described as used for various ore sizes. Mention is also made of a small plant for the magnetic

* *Berg- und Hüttenmännisches Jahrbuch der k. k. Bergakademien*, vol. xlv.

† *School of Mines Quarterly*, vol. xxi. pp. 28-47, 136-169, 239-260.

‡ Paris Congress on Mining and Metallurgy, 1900 (advance proof).

§ *Oesterreichische Zeitschrift für Berg- und Hüttenwesen*, vol. xlviii. pp. 229-231; with illustrations.

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REFRACTORY MATERIALS.

Fireclay.—H. Seger * and E. Cramer give analyses of the raw and burnt clay from Breitscheid, Germany. Clay I. has a melting-point about equal to the Seger cone No. 34, while the melting-point of clay II. lies between those of the Seger cones Nos. 32 and 31.

| | I. | | II. | |
|----------------------------|-----------|-----------|-----------|-----------|
| | Raw. | Burnt. | Raw. | Burnt. |
| | Per Cent. | Per Cent. | Per Cent. | Per Cent. |
| Loss on ignition | 14.54 | ... | 15.48 | ... |
| Silica | 45.74 | 53.49 | 53.78 | 63.63 |
| Alumina | 37.84 | 44.25 | 28.89 | 34.18 |
| Ferric oxide | 1.08 | 1.28 | 1.08 | 1.28 |
| Lime | trace | trace | trace | trace |
| Magnesia | nil | nil | nil | nil |
| Alkalies | 0.92 | 1.07 | 0.84 | 0.98 |
| Total | 100.12 | 100.07 | 100.07 | 100.07 |

This clay was known and used in the Middle Ages.

H. Wedding † gives the following analysis of a kaolin from Mituiski, in Japan, which is used in the manufacture of the bricks employed in the chequer-work of the regenerators of open-hearths:—

| | Per Cent. |
|------------------------|-----------|
| Silica | 61.72 |
| Alumina | 36.67 |
| Ferric oxide | 0.63 |
| Magnesia | 0.29 |
| Potash | 0.98 |
| Soda | 0.10 |
| Total | 100.39 |

It has a very high melting-point, about that of the Seger cone No. 35. In manufacturing the bricks, 12 per cent. of pure burnt kaolin is mixed with unburnt clay. Of this a mixture is made of coarse and fine material obtained by separation by sifting. In this way bricks can be made that have a fine-grained surface, and do not hold the dust.

* *Stahl und Eisen*, vol. xx, p. 308.

† *Ibid.*, p. 773.

First Part

The first part of the document discusses the importance of maintaining accurate records of all transactions. It emphasizes that proper record-keeping is essential for the transparency and accountability of the organization. The text outlines the various methods used to collect and analyze data, ensuring that the information is reliable and up-to-date. It also mentions the role of different departments in this process, highlighting the collaborative effort required to achieve the organization's goals.

Second Part: Financial Statements

The second part of the document provides a detailed overview of the financial statements for the current period. It includes a summary of the income statement, balance sheet, and cash flow statement. The text explains the various line items and their impact on the organization's overall financial health. It also discusses the challenges faced during the reporting period and the steps taken to address them. The section concludes with a brief analysis of the financial trends and a forecast for the future.

The third part of the document focuses on the operational aspects of the organization. It describes the various projects and initiatives that are currently underway, along with the resources allocated to each. The text highlights the progress made in each area and the challenges encountered. It also discusses the strategies implemented to improve efficiency and reduce costs. The section ends with a summary of the key findings and recommendations for future action.

avoided. It should be short, sharp, and clean. Combined water indicates the presence of kaolinite, and should therefore be low. The fluxes probably range from 4 to 5 per cent., but vary in amount according to the nature of the constituents, as the alkalies are more powerful fluxes than iron.

Graphite Crucibles.—W. F. Downs* deals with the occurrence, treatment, and application of graphite. The total annual production is not exactly ascertainable, but it certainly does not exceed 60,000 tons yearly. Austria and Ceylon are the leading producers, and a fair quantity is also obtained in Germany and Italy. The raw material is difficult to treat owing to the close approximation of the gangue to the graphite in its specific gravity. Both wet and dry methods are, however, in use. The manufacture of crucibles is then described on general lines, and their use is dealt with, after which the materials and mixtures used and the processes adopted are considered in greater detail.

Graphite in Bavaria.—In a report on the economical condition of Bavaria, F. D. Harford,† of the British Legation at Munich, says that graphite is one of the most valuable minerals found in Bavaria, and represents almost a monopoly for the country, as the only formidable competitor in the supply of natural graphite is Ceylon. The production in Ceylon has, however, decreased in the last six years from 30,000 tons to 12,000 to 15,000 tons annually, causing a great rise in prices, as the deficit could not be made good from other sources. The price of Ceylon graphite ranges from £50 to £75 per ton. In Bavaria the graphite deposits are found near Passau, and are inferior to the Ceylon graphite, as, while the latter is nearly pure, the former has about 60 to 75 per cent. of earthy substances mixed with it. The Passau graphite, however, can be purified by a very simple and inexpensive process, and a substance produced that is quite equal to the Ceylon graphite. Unfortunately this process is little used, as the deposits are spread amongst a number of small proprietors, who work on a small scale, in the cheapest manner possible. The result is that there is a waste of raw material, of which it is said that nearly 90 per cent. is absolutely thrown away owing to the unscientific system of

* *Iron Age*, April 19, 1900, p. 8; May 3, p. 3; May 10, p. 9; May 24, p. 5; June 14, p. 26.

† Foreign Office Report, September 1900.

FUEL.

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I.—CALORIFIC VALUE.

Calorimetry.—C. V. Kerr* gives some notes on the Berthier method of determining the calorific value of coal by weighing the buttons of lead produced on fusing a mixture of litharge and the powdered fuel. In view of the fact that a different amount of heat is lost in the products for combustion from the hydrogen and the carbon in the fuel, and that allowances may be made for the bituminous or non-bituminous nature of the coal, fairly comparative results may be obtained, and of these a number are given.

Euchène † has presented to the International Gas Congress at Paris a lengthy paper dealing with the thermal reactions that occur during the distillation of coal. The amount of the products and the heat liberated or absorbed in their production is given for several varieties of coal and peat, the results being shown in a large number of tables.

W. Kent ‡ discusses the economical use of fuel, and summarises the recent researches on the calorific value, with special attention to the work of Lord and Haas.

E. D. Meier § gives a popular account of the amount of energy contained in a pound of coal, and of the amount of work it is capable of giving.

* *Transactions of the American Society of Mechanical Engineers*, vol. xxi. pp. 304-316.

† *Journal of Gas Lighting*, October 1900.

‡ *The Mineral Industry*, vol. viii. pp. 124-157.

§ *Cassier's Magazine*, vol. xviii. pp. 65-70.

Paragraph 1

The first paragraph of the text discusses the importance of maintaining accurate records of all transactions. It emphasizes that proper record-keeping is essential for the integrity of the financial system and for the ability to detect and prevent fraud. The text also mentions that records should be kept for a sufficient period of time to allow for a thorough audit.

Paragraph 2

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how far these rays might be utilised in ascertaining the percentages of ash in coal had shown that the permeability of one and the same seam for these rays varied in different parts to such an extent as to render them useless as a guide as to the ash contents. The author concluded that while any slate mixed with the coal was relatively of an approximately good degree of permeability, small admixtures of the oxides of the heavy metals greatly reduce the permeability of the coal for these rays. The author has since investigated this point, and now publishes the results obtained. In these last experiments the author first selected some samples which were found by the Röntgen rays to be very pure, and then powdered these very fine. The powdered samples were then carefully mixed and the ash determined. This was found to be 1.66 per cent. Six different samples of slate, shale, and blackband were then powdered and passed through the same sieve, and the percentages of iron and residues after ignition determined. Six mixtures were then made of the coal samples on the one hand, and of these powdered materials on the other, in such a way that the resulting mixtures each contained 10 per cent. of ash. For control purposes three of these mixed powders were again examined, the results proving them to be of the composition desired. They were then examined under similar conditions by the Röntgen rays, and the photographs obtained are now shown. The percentage of iron in the samples varied from 0.07 to 5.4, although, as stated above, the total ash contents were identical in each case. That sample which contained the least iron in the ash gave the clearest photograph, whilst that which contained most iron gave the worst, the other samples occupying intermediary positions in accordance with their varying iron contents. Hence it follows that the use of the Röntgen rays for fuel examinations, the author points out, is absolutely worthless, as it is the total ash contents which it is desired to determine by their aid.

The Origin of Coal.—At the Bradford meeting of the British Association, the origin of coal and cognate matters were dealt with in several papers, including the following:—W. J. Sollas, on “A Concealed Coalfield beneath the London Basin;” W. Gibson, on “Rapid Changes in the Thickness and Character of the Coal Measures of North Staffordshire;” R. Kidson, on the “Flora of the Coal Measures;” A. Strahan, on the “Origin of Coal;” A. C. Seward, on “Botanical Evidence bearing on the Climatic and other Physical

such as never occurred either before or after that period, of dominant giant cryptogams, extensive plains of sedimentation, and advantageous climatic conditions. To advance our knowledge of the origin of coal several things were necessary, the chief being the importance of the study of the chemical composition of fireclays and other accompaniments of coal, in addition to coal itself; the continuation of Dr. Sorby's petrological work on the origin of grains of mechanically formed rocks, such as sandstones; the studies of fauna and flora throwing light on physical and climatic conditions; and efforts to discover over what periods coal formation occurred in exceptional amount.

A. C. Seward thinks that the alleged uniformity in the climate and vegetation during the coal period was exaggerated. It was important to bear in mind the progress of plant evolution as a factor. There was in coal-seams an abundance of spores with filamentous or hooked appendages, and their presence was probably due to floating or wind dispersal; and so also with detached stems and roots. Concerning the manner of formation of coal, A. C. Seward instanced the structure of calcareous nodules found in coal-seams, in which the preservation of delicate tissues, the occurrence of fungal hyphæ, and the petrification of stigmatic appendages was evidence in favour of the subaqueous accumulation of the plant *débris* found in the nodules. If ordinary coal were microscopically examined, it was found to contain spores—in abundance in cannel coal—fragments of tissues, bacteria, and the ground substance of coal. Boulders and coal-balls were also included in the seams. Hence he thought that the seams were not the result of growth in one place, nor of drifting, but of the accumulation of vegetable *débris*, derived chiefly from plants growing on the surface of large lakes and pools near to the borders, where they died and were carried out by gently flowing water and sank to the bottom over the whole water area.

Much discussion took place, and in the course of it P. F. Kendall combated A. Strahan's theory of sedimentation. There were wide extents of comparatively uniform thickness not only of the coal itself, but also of the over- and under-lying areas, such as the layer of black shale covered with marine organisms over an area of 700 square miles from Bradford to Nottingham. In respect of the purity of coal, the proportion of mineral ash was very small, and there was an absence of molluscs, fishes, or minute crustacea, and no trace of aquatic animals in the coal-beds, though they existed in the layers above. There was, again, no coal-bed without a seat-earth or under-clay penetrated by roots of trees; and there was an entire absence of alkalies, which was characteristic of an exhausted soil.

Frequency of the α and β forms

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contains 52 per cent. of carbon, 3 per cent. of hydrogen, 16 per cent. of oxygen, and 4 per cent. of ash, and from Buschtiehrad, which contains 60 per cent. of carbon, 3 per cent. of hydrogen, 11 per cent. of oxygen, and 15 per cent. of ash.

Coal in Bosnia.—The mining industry of Bosnia continues to make satisfactory progress. The interesting monograph written by Franz Poech on the occasion of the Mining Congress at the Paris Exhibition, which has been published in book form, clearly shows the importance of the mineral resources of the country, the chief mineral products being rock salt, iron ore, brown coal, manganese ore, copper ore, and iron pyrites. The administration of the mines is regulated by a law promulgated in 1881. Most of the mines and works belong to the Government. The reason of this is that after the occupation of the country few private capitalists came forward to establish industries, and the Government, full of good intentions to improve the economic conditions of the population, undertook to develop the mineral resources of the country. The results obtained have been satisfactory financially, and the Government has aimed at improving the methods of mining and the social condition of the population employed. Numerous houses have been built for the workpeople. For example, at the Kreka colliery there is a colony of sixty houses, each built for two families. These houses are one-storied, and each dwelling consists of a living room, a kitchen, a larder, and a stable, with a small garden in front and a kitchen-garden behind. For large families and for foremen one or two rooms are added. Married workmen pay for lodging 5 francs a month, bachelors 2 franca. Each mine is provided with an ambulance and co-operative stores, and sick clubs and insurance funds have been organised. At the end of last year there were 2090 members subscribing to the insurance fund.

In Bosnia and Herzegovina there are some extensive beds of brown coal, but no deposits of bituminous coal have yet been found. The coal-mining industry has grown in a remarkable manner since the first colliery was started at Zenica, as is shown by the fact that in 1880 the output was 500 tons, whilst in 1899 it was 303,425 tons. The coal is of Oligocene age. It is of a black colour, and yields on analysis :—

| | Zenica. | Zgoeca. |
|--------------------|---------|---------|
| Moisture | 11·80 | 6·55 |
| Ash | 6·55 | 12·32 |
| Sulphur | 2·48 | 2·01 |

Coal in France.—An exhaustive paper on the coalfield of the Gard has been published by M. Bertrand.* The monograph covers more than 100 pages, and is illustrated by numerous geological maps and sections. The results of the author's investigations are most encouraging from the point of view of the future resources of the region.

J. Gosselet † gives some notes on thirty-eight recent borings made in the North of France in search of the coal-basin. A map is appended.

F. Drobnia ‡ observes that the extensive Belgian coalfield, which is a continuation of the Ruhr, Inde, and Wurm coal-basins, passes into France in the neighbourhood of Condé, and then stretches for a distance of 68 miles in the Departments of the Nord and Pas-de-Calais, as far as Boulogne. The width of the field is but narrow, and the coal-seams are covered by tertiary deposits, frequently over 650 feet in thickness. Beds of quicksand are of frequent occurrence, especially in the Nord basin, and these greatly interfered with the progress of the coal industry in these fields. Thus, while in Belgium, in the neighbouring province of Hennegau, coal-mining commenced in the thirteenth century, and at the end of the seventeenth century there were some 120 shafts there with 5000 workpeople, the important coal deposits of France still lay quite untouched and unknown at the latter date. It was only in 1716 that a citizen of the town of Condé, thinking that the Belgian field must stretch into France, and investigating the question by operations in the vicinity of the village of Fresnes, proved the truth of his theory. His operations were very successful, and it is from these that the coal-mining industry of the North of France dates. Up to 1840 it was only in the Nord Department that coal was raised, and it was not until 1850 that coal-mining in the Pas-de-Calais became of any importance. The real progress of both Departments has been made since the year 1869.

The coal deposits are somewhat irregular in their occurrence, and occasionally the seams are greatly disturbed. The general strike of the beds is from east to west, passing subsequently in the Pas-de-Calais basin to south-east to north-west. The seams mined in the Nord basin vary in thickness, from 18 to 33 inches, with a local enrichment to 13 feet in the coal of the *grand veine* near Dutemple. In the Pas-de-Calais conditions are more favourable, the beds being far more

* *Annales des Mines*, vol. xvii. pp. 505-618.

† *Transactions of the Institution of Mining Engineers*, vol. xviii. pp. 317-324.

‡ *Oesterreichische Zeitschrift für Berg- und Hüttenwesen*, vol. xlviii. pp. 439-442, with sheet of illustrations.

regular and less disturbed, and the thickness of the seams reaching to over 8 feet. The author describes the systems of ventilation in use. Most of the collieries possess round walled ventilating shafts, which are also used for winding. In the colliery itself the ventilation doors are sometimes provided with explosion valves. The lamps are in the Nord basin all closed and of the Marsaut type. Open lights are occasionally used in the Pas-de-Calais. Transport in the colliery is usually done by ponies, only a few of the larger collieries having machine-driven plants for this purpose. The author describes generally the appliances and the systems of coal-getting adopted. Both long-wall and pillar-and-stall methods are in use, the latter far more frequently. The collieries usually have good repairing-shops, and are generally well provided with above-ground plant.

An important memoir was read by Grand'Eury* before the Academy of Sciences, on the formation of coalfields, with special reference to the Loire.

J. Delas† has published an important paper on the lignite deposits of Sarladais, the output of which is 3882 tons annually. The author estimates that 14,000,000 tons of lignite are available.

Rock Temperature in the Ruhr Coalfield.—Kette‡ publishes an exhaustive paper on the temperature of the strata in the Ruhr coalfield. The results of the observations recorded show that on an average the miners of the Ruhr coalfield have to reckon on an increase in rock temperature of 1° C. for every 92 feet, but that for those mines which are worked under very thick superincumbent strata a somewhat more rapid increase of temperature may be expected. This may, perhaps, amount to 1° C. for every 82 feet. Thermal gradients of 82 to 100 feet have hitherto been encountered only exceptionally, and are due to the action of hot springs and other special local conditions.

Quite a number of mineral springs have been met with in the Ruhr collieries as these have got deeper. It has now been ascertained that, at great depth, a bed of potassium salts underlies this field. The oldest and best known of such mineral springs is that of the Königsborn colliery, near Unna, which was known in the fourteenth century.§

* *Revue Scientifique*, August 4, 1900.

† *Bulletin de la Société de l'Industrie Minérale*, vol. xiii. pp. 717-776.

‡ *Glückauf*, vol. xxxvi. pp. 733-740.

§ *Oesterreichische Zeitschrift für Berg- und Hüttenwesen*, vol. xlviii. p. 533.

and then attempting to cake it—without success; but it has occurred to him that the removal of the water, which is the first thing to come away on heating, leaves the coal in a porous state, and thus facilitates the rapid evolution of those hydrocarbons in a gaseous form which, if retarded, would liquefy, and thus form the cementing material of the coke. To test this theory, he tried heating some of the coal in Faraday tubes, where they were subjected to the pressure of the gases they evolved, and succeeded in getting a very fairly coherent coke.

Coal in Victoria.—J. Stirling has described the fossil flora of South Gippsland. The memoir has been published by the Department of Mines of Victoria as one of the special reports on the Victorian coalfields.

Coal in Natal.—W. T. Heslop * describes the coalfields of Natal, and gives the geological classification of the district. In the Cape Colony the coal measures are found overlying the Beaufort beds; at Vereeniging they lie directly on the Dwyka conglomerate; and in the Brakpan and parts of the Middelburg district they also overlie a conglomerate, which is probably of Dwyka age, although different in character from what is generally associated with the Dwyka conglomerate, the matrix being a coarse sandstone instead of a fine hard blue shale; but the enclosed pebbles and boulders are the same—i.e. quartz, quartzite, slate, and granite from the older formations. At Cypherfontein, to the south of Krugersdorp, the coal lies directly on the dolomite, and at Boksburg, on the Witwatersrand formation, the Main Reef series passes directly under the workings of the Wishaw Colliery. South African coal is generally considered to be a sub-aqueous and lacustrine deposit. Professor Green found in some of the Cape Colony coal, under microscopic examination, a distinct concretionary structure, and the writer has observed the same peculiarity in coal from the Brakpan district of the Transvaal, where, after weathering, the concretionary layers of carbonaceous matter readily peeled off. In the Natal coalfield the seams have been found at all depths up to 500 feet, but most of the existing mines are working at depths of less than 300 feet. The deepest shaft at present is that of the Durban Collieries Syndicate at Dannhauser, which is 500 feet deep. It is probable that workable coal may be found at a greater depth on the western portion of the coalfields, but up to the present it remains unproved. The occurrence of dolerite is extensive, and in certain

* *Transactions of the Institution of Mining Engineers*, vol. xviii. pp. 410-430.

The results of the study show that the use of the proposed system is feasible and effective. The system was able to detect and classify the different types of faults in the system. The results of the study show that the use of the proposed system is feasible and effective. The system was able to detect and classify the different types of faults in the system.

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1. The first step is to identify the problem or question that needs to be answered. This involves understanding the context and the specific information required.

1. The first step in the process is to identify the problem or issue that needs to be addressed. This involves gathering information and understanding the context of the problem.

M'Alester-Lehigh coalfield, Indian Territory. The coals are all highly bituminous. The volatile matter in no instance is less than 37 per cent., and the fixed carbon averages 52 per cent. There are 58 square miles of workable coal in the Hartshorne bed, 60 square miles in the M'Alester bed, and 25 square miles in the Lehigh district.

Coal in Kansas.—Charles R. Keyes* discusses the correlative relations of certain subdivisions of the coal measures of Kansas, and calls attention to similarity of results obtained forty years ago, and conclusions arrived at by recent workers.

The Trans-Mississippian Coal.—C. R. Keyes† sketches the geological position of the coal-bearing rocks in the great western interior coal basin on the west of the Mississippi. The Carboniferous system is now divided into the Upper or Missourian series and the Lower or Des Moines series, and these are again further subdivided. Over 90 per cent. of the total coal production comes from the Cherokee shales at the base of the Des Moines series, taking the average of Iowa, Kansas, Missouri, Arkansas, and Indian Territory, and the value of this horizon is almost sure to increase.

Coal in Michigan.—A. C. Lane‡ gives a sketch map of the coal basin of Michigan, where the output for 1899 was over half a million tons. The increase in the production has been rapid within the last few years, but the extensive forests and other matters have delayed the development. The usual thickness of the seams worked is 2½ to 4 feet, at a depth from 100 to 300 feet. Many of the coals contain much sulphur. The various mines are shortly described.

Coal in Missouri.—David White§ has prepared a monograph of the fossil flora of the lower coal measures of Missouri. As the first comprehensive presentation of the flora of any zone of the coal measures in the trans-Mississippi region it furnishes valuable material for comparison and correlation of these beds with the eastern coalfields.

Coal in New Mexico.—C. L. Herrick|| and T. A. Bendrat, in a paper on the identification of an Ohio coal measures horizon in New

* *American Geologist*, June 1900.

† *Engineering and Mining Journal*, vol. lxix. pp. 528-529.

‡ *Ibid.*, vol. lxix. p. 767, vol. lxx. p. 12.

§ *United States Geological Survey Monographs*, vol. xxxvii.

|| *American Geologist*, April 1900.

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Coal in China.—A recent consular report by Carles of Tientain gives a number of particulars relating to coal and coal-mining in China, and deals more especially with the question of transport.

P. Fouletier * describes the Kebao collieries, Tonkin.

T. Webster † describes the Tong colliery, Kaiping, North China. There are thirteen seams, dipping from 45° to 90°, and nine are workable. The pillar-and-stall system is employed. The winding, pumping, and other plant is shortly described.

Coal in Chili.—Some interesting details of coal in Chili have been published.‡ The calorific powers of some of the principal coals are as follows:—

| Talcahuano:— | Calories. |
|----------------------------------|-----------|
| Talcahuano | 5468 |
| Penco | 5764 |
| Santa Ana | 5559 |
| Dichato | 4913 |
| Lautaro:— | |
| Coronel | 5630 |
| Lota | 6472 |
| Arauco:— | |
| Colico | 5950 |
| Curanilahue | 6182 |
| Lebu | 6472 |
| Nielol (lignite) | 5123 |
| Merced (lignite) | 2563 |
| Quilacoya (anthracite) | 7320 |

Analyses of lignite from various localities gave the following results:—

| | I. | II. | III. | IV. |
|-----------------|------|------|-------|------|
| Water | 18·4 | 17·6 | 18·80 | 25·5 |
| Gas | 31·6 | 38·8 | 28·85 | 18·0 |
| Coke | 36·5 | 40·2 | 50·20 | 22·0 |
| Ash | 13·5 | 3·4 | 2·15 | 34·5 |

I. Chumai outcrop; II. Malalhue; III. Nielol; IV. Los Corrales. Last year the imports of coal into Chili amounted to 661,669 tons.

Coal in New Caledonia.—Coal is known to exist in abundance in the French colony of New Caledonia,§ and is stated to be of fairly

* *Comptes Rendus de la Société de l'Industrie Minérale*, 1900, pp. 45-61.

† *Proceedings of the South Wales Institute of Engineers*, vol. xxii. pp. 24-36.

‡ *Revista Comercial e Industrial de Minas*, vol. i. No. I. (February).

§ *Colliery Guardian*, vol. lxxx. p. 386.

The first part of the report deals with the general situation of the country. It is a very interesting and informative study of the country's development. The author has done a great deal of research and has gathered a wealth of material. The report is well written and is a valuable contribution to the study of the country's development. It is a must-read for anyone interested in the country's development.

1. The General Situation

The general situation of the country is very interesting. The country has a long history and a rich culture. It is a very beautiful country with many beautiful cities and towns. The country is a very important country in the world. It is a country that has made many contributions to the world. The country is a country that is full of life and energy. It is a country that is full of hope and promise. The country is a country that is full of opportunity. It is a country that is full of potential. The country is a country that is full of everything that makes life worth living.

2. The Economy

The economy of the country is very strong. It is a country that has a high standard of living. It is a country that has a high level of education. It is a country that has a high level of health care. It is a country that has a high level of social security. It is a country that has a high level of economic growth. It is a country that has a high level of economic development. It is a country that has a high level of economic progress. It is a country that has a high level of economic achievement. It is a country that has a high level of economic success. It is a country that has a high level of economic prosperity. It is a country that has a high level of economic well-being. It is a country that has a high level of economic happiness. It is a country that has a high level of economic contentment. It is a country that has a high level of economic satisfaction. It is a country that has a high level of economic fulfillment. It is a country that has a high level of economic achievement. It is a country that has a high level of economic success. It is a country that has a high level of economic prosperity. It is a country that has a high level of economic well-being. It is a country that has a high level of economic happiness. It is a country that has a high level of economic contentment. It is a country that has a high level of economic satisfaction. It is a country that has a high level of economic fulfillment.

III.—CHARCOAL.

The Manufacture of Gas from Charcoal.—J. M. Neil * describes the Riché continuous retort for the manufacture of charcoal and gas. The retorts are vertical and are heated externally. Charcoal is withdrawn at the bottom, which has an L-shaped extension, and wood is charged at the top. The gas is also drawn off below. A ton of wood is stated to produce 400 lbs. of charcoal and 25,000 cubic feet of gas, containing 44·2 per cent. of hydrogen, 22·0 of carbon monoxide, and 21·3 of carbonic anhydride.

Dry Distillation of Fir Wood.—Irminger † describes some tests of the dry distillation of fir. The total weight of the products of distillation—gas, pyroligneous acid, tar, and charcoal—was within 4 per cent. of the weight of the wood charged into the retorts.

IV.—COKE.

Beehive Ovens.—A description is given ‡ of the beehive coke-oven plant at Chickamauga, in Georgia, with dimensions of the ovens, and an illustration of the inclined track and hauling plant for running the loaded trucks over the ovens.

F. C. Keighley § gives an illustrated description of the Connellsville coke district, with especial reference to the mining of the coal.

A. W. Evans || describes the coking plant of the Durham Coal and Coke Company. An illustrated description of a plant on Lookout Mountain, Georgia, is given.

A brief description has been published ¶ of the Welsh coke-ovens used in West Virginia in place of beehive ovens.

Coke-Oven Plant of the Concordia Colliery.—The coke-oven plant of the Concordia colliery, Moravian-Ostrau, is stated by W.

* *Engineering and Mining Journal*, vol. lxx. pp. 281-282.

† *Ingeniören*, Copenhagen, 1899, pp. 311-317; *Minutes of Proceedings of the Institution of Civil Engineers*, vol. cxlii. p. 439.

‡ *Colliery Guardian*, vol. lxxx. p. 610.

§ *Engineering Magazine*, vol. xx. pp. 17-40.

|| *Mines and Minerals*, vol. xxi. pp. 49-51.

¶ *Ibid.*, p. 11.

The ordinary dimensions of an oven are as follows :—Total length, 29 feet 6 inches ; height, 5 feet 7 inches ; breadth, from 14·1 inches for a coal with but little volatile matter, to 19·7 inches for a coal containing a higher percentage of volatile constituents. Of late some ovens of larger dimensions have been erected, with a result that the cubic contents of the oven have been raised in these cases from the average of 238 cubic feet to 353 cubic feet. An oven of the larger size yields annually about 1800 tons of coke. The finished coke is pressed out in a thin layer, and the quenching is stated to be consequently rapidly effected, and only a relatively small quantity of moisture to be retained. It is preferred to cool the gas at once after it escapes from the ovens, with a view to avoid tar settling in improper places in the subsequent passage of the gases through the condensing plant, and so causing inconvenience. The charge of an oven is about four to five tons, and the time required for coking is less than twenty-four hours. The wages paid are not higher than in ovens of the ordinary kind. To these, however, must be added the wages connected with the cooling and washing plants.

There is no special arrangement for the pre-heating of the blast other than in the utilisation of channels beneath the oven bed. In these the temperature of the air is raised to 200° or 300° C. Special attention is paid to a careful regulation of the gas supply to each oven, the gas openings leading from the ovens to the main gas channel being of such a size as to cause the draught to be of equal strength for each oven. Boilers are placed between the oven and the stack. According to the kind of coal being coked, the heating surface of each oven varies from 64·6 to 134·5 square feet. The temperature of the gases, as these escape into the stack, is stated not to exceed 200° C., even when the furnace is working hot. The steam raised in the boilers by the waste heat usually suffices for the coke-oven plant, and also the ammonium sulphate plant. Only a portion of the gas produced is used for heating purposes. The quantity of gas that remains in excess varies greatly, and is dependent on the character of the coal. It is stated, however, to be at least one-fourth of the total quantity produced, even when a coal is being coked that is low in volatile constituents. The larger the quantity of these, the greater is the available excess of gas. When coal low in volatile constituents is being coked, the quantity of water converted into steam by the direct use of the waste heat of the oven is stated to amount to 0·6 lb. for each pound of coal charged. If the excess of gas is also used for steam-

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| Age Group | Education Level | Percentage of Respondents (%) |
|-----------|-----------------|-------------------------------|
| 18-29 | High School | ~35 |
| | Some College | ~45 |
| | Bachelor's | ~55 |
| | Graduate | ~65 |
| 30-49 | High School | ~45 |
| | Some College | ~55 |
| | Bachelor's | ~65 |
| | Graduate | ~75 |
| 50-69 | High School | ~55 |
| | Some College | ~65 |
| | Bachelor's | ~75 |
| | Graduate | ~85 |
| 70+ | High School | ~65 |
| | Some College | ~75 |
| | Bachelor's | ~85 |
| | Graduate | ~95 |

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the 1990s, the number of people in the United States who are 65 years of age or older has increased by 50 percent, and the number of people 75 years of age or older has increased by 100 percent. The number of people 85 years of age or older has increased by 200 percent. The number of people 95 years of age or older has increased by 400 percent. The number of people 100 years of age or older has increased by 1,000 percent. The number of people 105 years of age or older has increased by 2,000 percent. The number of people 110 years of age or older has increased by 4,000 percent. The number of people 115 years of age or older has increased by 8,000 percent. The number of people 120 years of age or older has increased by 16,000 percent. The number of people 125 years of age or older has increased by 32,000 percent. The number of people 130 years of age or older has increased by 64,000 percent. The number of people 135 years of age or older has increased by 128,000 percent. The number of people 140 years of age or older has increased by 256,000 percent. The number of people 145 years of age or older has increased by 512,000 percent. The number of people 150 years of age or older has increased by 1,024,000 percent. The number of people 155 years of age or older has increased by 2,048,000 percent. The number of people 160 years of age or older has increased by 4,096,000 percent. The number of people 165 years of age or older has increased by 8,192,000 percent. The number of people 170 years of age or older has increased by 16,384,000 percent. The number of people 175 years of age or older has increased by 32,768,000 percent. The number of people 180 years of age or older has increased by 65,536,000 percent. The number of people 185 years of age or older has increased by 131,072,000 percent. The number of people 190 years of age or older has increased by 262,144,000 percent. The number of people 195 years of age or older has increased by 524,288,000 percent. The number of people 200 years of age or older has increased by 1,048,576,000 percent. The number of people 205 years of age or older has increased by 2,097,152,000 percent. The number of people 210 years of age or older has increased by 4,194,304,000 percent. The number of people 215 years of age or older has increased by 8,388,608,000 percent. The number of people 220 years of age or older has increased by 16,777,216,000 percent. The number of people 225 years of age or older has increased by 33,554,432,000 percent. The number of people 230 years of age or older has increased by 67,108,864,000 percent. The number of people 235 years of age or older has increased by 134,217,728,000 percent. The number of people 240 years of age or older has increased by 268,435,456,000 percent. The number of people 245 years of age or older has increased by 536,870,912,000 percent. The number of people 250 years of age or older has increased by 1,073,741,824,000 percent. The number of people 255 years of age or older has increased by 2,147,483,648,000 percent. The number of people 260 years of age or older has increased by 4,294,967,296,000 percent. The number of people 265 years of age or older has increased by 8,589,934,592,000 percent. The number of people 270 years of age or older has increased by 17,179,869,184,000 percent. The number of people 275 years of age or older has increased by 34,359,738,368,000 percent. The number of people 280 years of age or older has increased by 68,719,476,736,000 percent. The number of people 285 years of age or older has increased by 137,438,953,472,000 percent. The number of people 290 years of age or older has increased by 274,877,906,944,000 percent. The number of people 295 years of age or older has increased by 549,755,813,888,000 percent. The number of people 300 years of age or older has increased by 1,099,511,627,776,000 percent. The number of people 305 years of age or older has increased by 2,199,023,255,552,000 percent. The number of people 310 years of age or older has increased by 4,398,046,511,104,000 percent. The number of people 315 years of age or older has increased by 8,796,093,022,208,000 percent. The number of people 320 years of age or older has increased by 17,592,186,044,416,000 percent. The number of people 325 years of age or older has increased by 35,184,372,088,832,000 percent. The number of people 330 years of age or older has increased by 70,368,744,177,664,000 percent. The number of people 335 years of age or older has increased by 140,737,488,355,328,000 percent. The number of people 340 years of age or older has increased by 281,474,976,710,656,000 percent. The number of people 345 years of age or older has increased by 562,949,953,421,312,000 percent. The number of people 350 years of age or older has increased by 1,125,899,906,842,624,000 percent. The number of people 355 years of age or older has increased by 2,251,799,813,685,248,000 percent. The number of people 360 years of age or older has increased by 4,503,599,627,370,496,000 percent. The number of people 365 years of age or older has increased by 9,007,199,254,740,992,000 percent. The number of people 370 years of age or older has increased by 18,014,398,509,481,984,000 percent. The number of people 375 years of age or older has increased by 36,028,797,018,963,968,000 percent. The number of people 380 years of age or older has increased by 72,057,594,037,927,936,000 percent. The number of people 385 years of age or older has increased by 144,115,188,075,855,872,000 percent. The number of people 390 years of age or older has increased by 288,230,376,151,711,744,000 percent. The number of people 395 years of age or older has increased by 576,460,752,303,423,488,000 percent. The number of people 400 years of age or older has increased by 1,152,921,504,606,846,976,000 percent. The number of people 405 years of age or older has increased by 2,305,843,009,213,693,952,000 percent. The number of people 410 years of age or older has increased by 4,611,686,018,427,387,904,000 percent. The number of people 415 years of age or older has increased by 9,223,372,036,854,775,808,000 percent. The number of people 420 years of age or older has increased by 18,446,744,073,709,551,616,000 percent. The number of people 425 years of age or older has increased by 36,893,488,147,419,103,232,000 percent. The number of people 430 years of age or older has increased by 73,786,976,294,838,206,464,000 percent. The number of people 435 years of age or older has increased by 147,573,952,589,676,412,928,000 percent. The number of people 440 years of age or older has increased by 295,147,905,179,352,825,856,000 percent. The number of people 445 years of age or older has increased by 590,295,810,358,705,651,712,000 percent. The number of people 450 years of age or older has increased by 1,180,591,620,717,411,303,424,000 percent. The number of people 455 years of age or older has increased by 2,361,183,241,434,822,606,848,000 percent. The number of people 460 years of age or older has increased by 4,722,366,482,869,645,213,696,000 percent. The number of people 465 years of age or older has increased by 9,444,732,965,739,290,427,392,000 percent. The number of people 470 years of age or older has increased by 18,889,465,931,478,580,854,784,000 percent. The number of people 475 years of age or older has increased by 37,778,931,862,957,161,709,568,000 percent. The number of people 480 years of age or older has increased by 75,557,863,725,914,323,419,136,000 percent. The number of people 485 years of age or older has increased by 151,115,727,451,828,646,838,272,000 percent. The number of people 490 years of age or older has increased by 302,231,454,903,657,293,676,544,000 percent. The number of people 495 years of age or older has increased by 604,462,909,807,314,587,353,088,000 percent. The number of people 500 years of age or older has increased by 1,208,925,819,614,629,174,706,176,000 percent. The number of people 505 years of age or older has increased by 2,417,851,639,229,258,349,412,352,000 percent. The number of people 510 years of age or older has increased by 4,835,703,278,458,516,698,824,704,000 percent. The number of people 515 years of age or older has increased by 9,671,406,556,917,033,397,649,408,000 percent. The number of people 520 years of age or older has increased by 19,342,813,113,834,066,795,298,816,000 percent. The number of people 525 years of age or older has increased by 38,685,626,227,668,133,590,597,632,000 percent. The number of people 530 years of age or older has increased by 77,371,252,455,336,267,181,195,264,000 percent. The number of people 535 years of age or older has increased by 154,742,504,910,672,534,362,390,528,000 percent. The number of people 540 years of age or older has increased by 309,485,009,821,345,068,724,781,056,000 percent. The number of people 545 years of age or older has increased by 618,970,019,642,690,137,449,562,112,000 percent. The number of people 550 years of age or older has increased by 1,237,940,039,285,380,274,899,124,224,000 percent. The number of people 555 years of age or older has increased by 2,475,880,078,570,760,549,798,248,448,000 percent. The number of people 560 years of age or older has increased by 4,951,760,157,141,521,099,596,496,896,000 percent. The number of people 565 years of age or older has increased by 9,903,520,314,283,042,199,193,993,792,000 percent. The number of people 570 years of age or older has increased by 19,807,040,628,566,084,398,387,987,584,000 percent. The number of people 575 years of age or older has

the 1990s, the number of people in the world who are under 15 years of age is expected to increase from 1.1 billion to 1.5 billion. The number of people aged 65 and over is expected to increase from 200 million to 400 million. The number of people aged 15 and over is expected to increase from 3.5 billion to 4.5 billion. The number of people aged 15 and over is expected to increase from 3.5 billion to 4.5 billion. The number of people aged 15 and over is expected to increase from 3.5 billion to 4.5 billion.

1. The first part of the paper discusses the importance of the research and the objectives of the study.

2. The second part of the paper discusses the methodology used in the study.

3. The third part of the paper discusses the results of the study.

4. The fourth part of the paper discusses the conclusions of the study.

5. The fifth part of the paper discusses the implications of the study.

furnace gas possesses the great disadvantage that it carries with it so much metallic dust that it may be unserviceable.

A plan has appeared * of the new coke-oven plant in the course of erection at Sidney, Cape Breton. It will contain eight batteries, each of fifty Otto-Hoffman ovens, to produce 1600 tons of coke daily. The gas will be used for lighting purposes, as with the Everett plant, near Boston, to which this is similar, and the coke will be used for the Dominion Iron and Steel Works.

R. Brunck † observes that a number of batteries of coke-ovens of the Brunck type have been erected in the Rhenish-Westphalian district. Improvements which were introduced as the result of practical experience are referred to by the author. These result in the two sides of the furnace being separately heated, the waste gases being withdrawn by separate flues from each side. A very considerable pre-heating of the air for the combustion is attained, this passing up through a kind of firebrick stove between the two channels through which the gases pass to the stack. In this way overheating of the brickwork is prevented, and a considerable portion of the heat saved which would otherwise have escaped with the waste gases. Details are given of the oven construction; and it is pointed out that the gases from the coal are exposed for a shorter time to the danger of combustion and the heat of the oven than in other systems, with the result that a higher percentage of by-product is attainable.

Illustrations are given of the coke-oven plant on this system at the Jules Chagot Works at Montceau-les-Mines, and at the Minister Stein Colliery of the Gelsenkirchen Company. At this latter place there are 120 ovens, which coke in the course of a year from 250,000 to 260,000 tons of coal, containing 10 to 12 per cent. of moisture; this yields from 2800 to 2900 tons of ammonium sulphate and some 7500 to 7800 tons of tar. Other plants illustrated include one of sixty ovens at the Alma colliery of the Gelsenkirchen Company, and one of thirty ovens at the Hoesch Steelworks near Dortmund.

W. G. Irwin ‡ discusses the general aspect of by-product coking in Western Pennsylvania, and briefly reviews its present condition and the advances recently made. The transfer of the ovens to the works is held to have many advantages, as, though the cost of transport of raw coal is greater, yet the excess gas may be used where it is wanted.

* *Colliery Guardian*, vol. lxxx. p. 801.

† *Stahl und Eisen*, vol. xx. pp. 685-690, with five illustrations and one plate.

‡ *Engineering and Mining Journal*, vol. lxix. pp. 711-712.

Department of the Interior

Washington, D. C.

in Russia "Astatki" or "Masut." Their specific gravity is about 0.95, the calorific power being about 11,000. Theoretically they are capable of replacing about twice their weight of good brown coal, and do so in practice. At Baku, in 1898, these residues cost about 10s. the ton, but transport charges bring the price up to about 35s. the ton at Moscow, or half that at Saratov, a town on the Volga. Notwithstanding this, these residues are used with commercial advantage in open hearths and heating furnaces at Moscow. Works using petroleum as fuel make neither smoke nor clinker. No fire-bars are required, and no gas producers. There is no loss of fuel either, as the petroleum is brought to the furnaces in closed vessels, and then burns with an almost theoretical degree of perfection. One great advantage of the use of petroleum is that the labour costs for firing are reduced to a minimum. There are three main types of firing methods with petroleum—(1) the pan method, (2) the drop method, and (3) the spraying method, in which the oil is, as it were, pulverised before use. Each of these is illustrated. In the first method a series of rectangular cast iron pans, from three to five in number, are placed one above the other, fitting closely to the walling at the sides. Between each two pans a slit is left of an area that has been carefully calculated, and through which the air streams that is to serve for the combustion. The naphtha residues flow into the upper pan through pipes from a large wrought iron tank which is placed at a higher level. By regulating the flow of oil, the whole of the pans may be kept full without overflowing. This pan system of firing possesses a certain analogy with the step grate. It is the oldest and simplest, but least economical, of the various methods. It is frequently employed, and is, indeed, not replaceable by other methods when it is a question of producing a temperature that is to be increased slowly. Very high temperatures can be attained by this method, especially if the air for the combustion is pre-heated. Crucible steel can, indeed, be made with this system of firing in the so-called Nobel furnace. It is, however, most applicable when it is not a question of producing a very high temperature. The second method is considerably better than the one just described, and is more frequently employed. In this method the oil flows out in drops or in thin streams from a number of small tubes placed side by side, or from a launder provided with a number of slits. In falling, it gets intimately mixed with air, and burns more readily and more completely than does the oil in the pan method. A higher temperature can, too, be more rapidly attained,

and there is less chance of loss of oil. The drop method from a pipe apparatus is better than that in which a launder with slits is employed, as the former is much more under control. This drop method is very useful for heating furnaces. The height of fall of the petroleum regulates the temperature that results. For small firings it is about 39 inches, and rises to double that in larger ones. The air for the combustion either takes the same course as the falling oil, or else passes upwards in the opposite direction. This system of firing has this one advantage over all others, that once started it involves no labour charges whatever in the case of furnaces that are constantly in use. The first and second methods differ from the third in that the oil falls or flows from a higher level, and still more distinctly in that the oil is not charged as such direct into the furnace, but is first gasified in a more or less small gasifying chamber, this space resembling the grate in the case of a furnace using solid fuel. In the third or spraying system a blow-pipe jet is used. The oil flows into the inner tube of a blow-pipe, compressed air or steam being forced through an outer tube surrounding the other. This air or steam meeting the oil as it flows out completely disseminates it, and producing an intimate admixture of air and steam, enables the most rapid degree of combustion to be attained. The gasification stage is avoided, and the combustion chamber is the furnace itself. This spraying method, in addition to an ideal degree of simplicity, has the further advantage that the flame may be given any desired length or direction, while the quantity of fuel can be regulated with the greatest precision, and any desired temperature can be attained. There is still another advantage, in that by varying the construction of the spraying appliance the flame may have any shape given to it that is wished for. For instance, in boiler-firing a long broad flame is desirable, the flame lapping the sides of the boiler-tube, and the author illustrates a modified form of burner which gives a flame of this shape. Other types are also shown. Thus, if a large space has to be equably heated, a pipe form is employed with a spiral-shaped opening, which results in the steam or compressed air attaining a rotary movement, and so giving a flame of conical form. Pipe forms are used in all kinds of fusion furnaces for the production of weld and ingot iron. Not only have open hearths and puddling furnaces been provided with such appliances, but two years ago a crucible steel furnace heated in this manner was erected. The fusion furnaces, with petroleum firing, are built on the regenerative system, in exactly the same form as for gas

firing. Four 15-ton open hearths of simple form at Moscow are described. These have petroleum firing on the spraying system. The river Volga, which offers the best transport line from the petroleum districts to the works, is thickly frozen over in winter, and this necessitates the works providing themselves with large storage reservoirs for the oil. These are of iron, and are cylindrical in form. Large stores of oil mean, of course, great danger from fire, and the works consequently only purchase residues whose flaming point is as high as possible above 120° C. It is not an uncommon thing to find, however, that ordinary raw oil is mixed in with the residues as an adulteration, and, indeed, to such an extent that the temperature at which the oil will fire may be reduced to as low as 80° C. The first cost of a naphtha plant for a works with two open hearths, one crucible steel furnace, six other furnaces, and some smiths' fires, &c., together with a boiler-house containing 11 boilers, amounted to 27,000 roubles, 15,000 of which was the cost of the storage vessel, the remainder being expended for two pumps, pipe lines, &c. The author, in conclusion, draws attention to the rapid rate of progress of the Russian iron industry.

C. M. Rolker * describes the Elmore ore concentration process as used at Glasdir, in Wales, for concentrating copper ore. The ore is mixed with oil and then thrown into water. The gangue sinks, but the sulphides remain floating with the oil, if the correct proportions are used.

Roux † gives some notes on the use of petroleum in the manufacture of coal briquettes.

C. F. Z. Caracristi ‡ gives statistics for the world's production of oil, and briefly describes the leading oil districts.

H. Guérin § summarises recent articles describing the best methods of using liquid fuel.

Chemistry of Petroleum.—A. A. Shukoff || and N. S. Pantjucoff describe their investigations on the existence of paraffin in Russian oils, and show that it may be extracted.

D. T. Day ¶ gives some notes on the variation of the crude oils from

* Paper read before the Institution of Mining and Metallurgy.

† Paper read before the Paris Petroleum Congress; *Petroleum Review*, vol. iii., Supplement, p. 80.

‡ *The Mining Industry*, vol. viii. pp. 454-466.

§ *Génie Civil*, vol. xxxvii. pp. 22-25, 36-39.

|| *Petroleum Review*, vol. iii. p. 153.

¶ Paper read before the Paris Petroleum Congress; *Petroleum Review*, vol. iii., Supplement, p. 9-10.

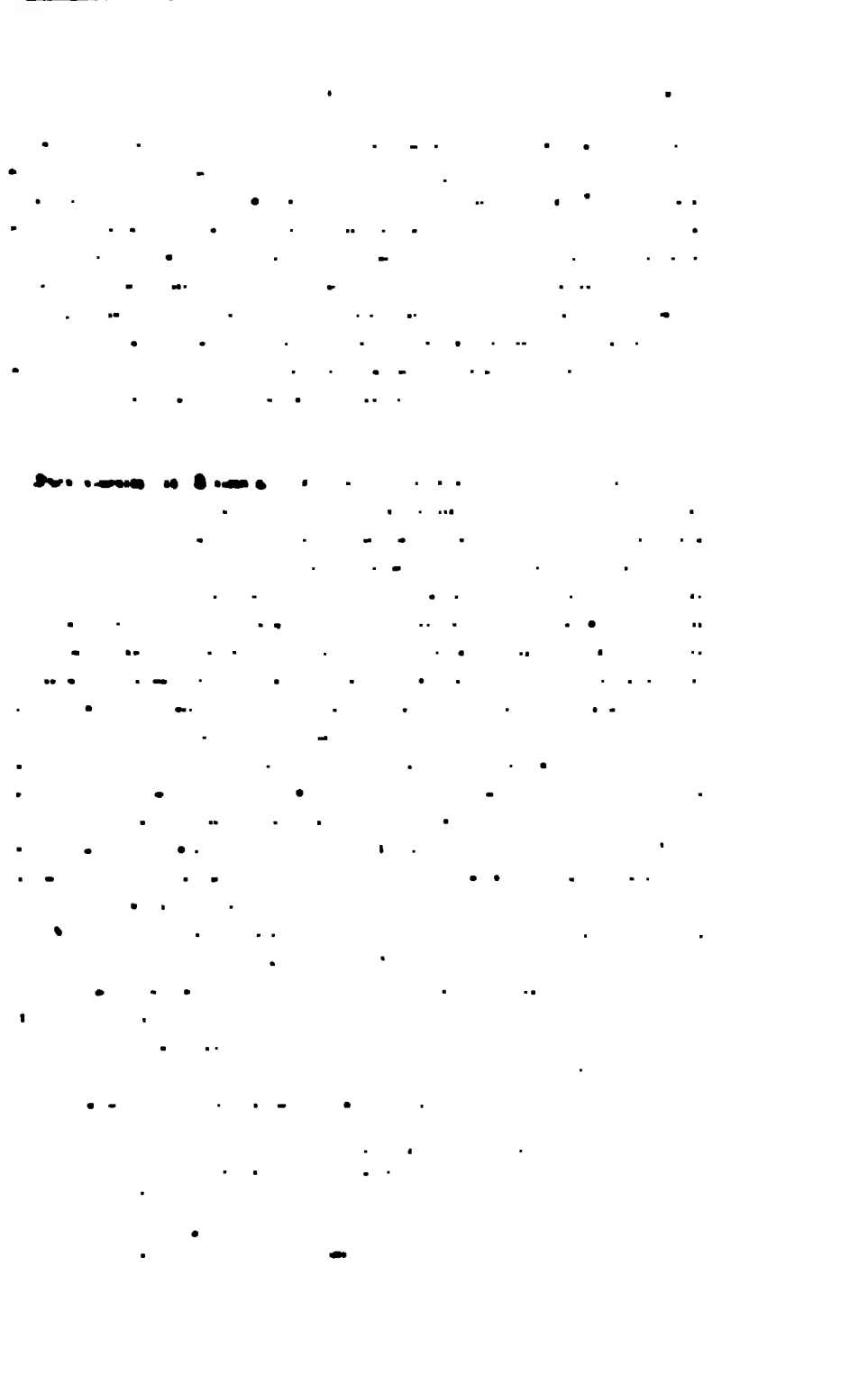
of the composition $C_{11}H_{20}O_2$, and, further, that nearly all petroleum contain oxidised compounds which are soluble in alkalis, more being present in the heavier than in the lighter oils. Sulphur and nitrogen are also found in some petroleum, but in small quantities only, and it is not yet definitely known in what form. The Berca oil was especially selected for examination in this investigation of Roumanian oils. It has a specific gravity of 0.8240 at 15° C. When distilled in an Engler apparatus it yielded :—

| Temperature. | Per Cent. |
|------------------------|-----------|
| Up to 150° C. | 23.19 |
| 150 to 300° C. | 46.30 |
| Residue | 30.20 |

This residue was rich in paraffin. Analysis showed the composition to be—

| Carbon. | Hydrogen. | Sulphur. |
|---------|-----------|----------|
| 85.08 | 13.71 | 0.20 |

The results of a very complete fractional distillation are given, as also are those of subsequent examinations of these distillates. The results showed that the oil contained large quantities of hydrocarbons of the benzene series. Other Roumanian petroleum contain these hydrocarbons, those of Casin and Resca only containing small quantities, while others contain more, such as those of Colibasi and Cămpeni. Roumanian petroleum vary very greatly in colour. That of Cămpeni-Părjol is transparent and of a light yellow colour, while that of Predeal possesses a light reddish colour. All the other Roumanian petroleum are opaque and show every variation of the darker colour between brown and black. A more or less green fluorescence is characteristic of them all. With regard to their density, the lightest oil, 0.7838 at 15° C., is that of Cămpeni-Părjol. The oil with the highest density, 0.9050, is that of Sărata-Tohani. Saligny states that the petroleum of Ocnita has the density 0.9443. As a rule the density varies from 0.79 to 0.87. Some of the oils have a pleasant, and others an unpleasant, smell. Almost all the Roumanian petroleum contain highly volatile constituents, and even gases. The degree of viscosity was tested by means of the Engler viscosimeter, and found to vary from 1.04 for the Cămpeni oil to 4.88 in the case of that from Sărata-Tohani. This latter oil contains somewhat large quantities of oxidation products, which are soluble in alkalis. The physical properties of the various commercial products that are obtained from the unrefined Roumanian oils are then described, and it is shown that many of them are well suited for the manufacture of



poods of refined oil, so that the present railway capacity will be increased. Siding accommodation is, however, very scanty, and the pipes and pumps used for filling the tank-waggons are inadequate, so that much time is lost. There are three pumping stations on the line, with Worthington pumps.

A. A. Shukoff and N. S. Pantjucoff * show that paraffin scale may be extracted from the residuals after lubricating oil has been extracted in many of the Russian petroleum.

Some notes on a new oil basin near the mouth of the Embla river have appeared.†

Petroleum in Turkey.—A. Adiassevich ‡ gives some notes on the occurrence of oil on the coast of the Sea of Marmora around Ganos, Hora, Sharkeni, and Gemlik. Several wells have been sunk by hand, and small quantities of oil have been found, as well as gas. A map of the district is given, showing the position of the wells, productive and barren, and of the localities where indications of oil were found.

Petroleum in Canada.—J. D. Noble § describes the Canadian oil industry, giving an account of the oil-producing region, the boring plant, the system of storage tanks, the method of pumping the wells, the geology of the oil, and other matters.

Petroleum in Wyoming.—In Bulletin No. 3, issued by the University of Wyoming, W. C. Knight describes the oil-fields of Crook and Uinta counties. The paper is illustrated by maps and sections, and the results of tests of samples of oil are appended.

Petroleum in Algeria.—H. Neuburger || deals at considerable length with a geological investigation of the Oran oil basin in Algeria, which, in his opinion, promises considerable developments. The various basins are described in detail.

Petroleum in Japan.—S. Takano ¶ gives some notes on the present situation of the oil industry in Japan. The oil-fields extend

* *Petroleum Review*, vol. ii. pp. 282-283.

† *Ibid.*, vol. iii. pp. 269-271.

‡ *Ibid.*, vol. ii. pp. 281, 327.

§ Paper read before the Paris Petroleum Congress; *Petroleum Review*, vol. iii., Supplement, pp. 3-5.

|| *Ibid.*, vol. iii., Supplement, pp. 47-52, 60-67.

¶ *Petroleum Review*, vol. iii. pp. 75-78.

age are intermediate. One company started work on the Marahu deposits, but on too large a scale, and failed accordingly, and no other attempts have been made to work them. The thickness of the beds ranges from 100 to 300 feet, and in many cases the shale gives 20 to 45 per cent. of volatile matter on distillation.

VI.—NATURAL GAS.

Natural Gas in Ontario.—E. Coste * gives an account of the discovery and occurrence of natural gas in Ontario. The first well of importance to strike the gas was at Ruthven in January 1889. Since then a large number of wells have been bored, and the logs of a considerable number of them are given. Only one well has reached the Trenton limestone, and most of the gas comes from the Guelph limestone and the Oriskany sandstone. The geology and the origin of the gas and gas-yielding strata are dealt with at some length, and it is shown that water-pressure alone is not sufficient to account for the high pressure at which the gas is found.

Natural Gas in Italy.—R. Nasini and R. Salvadori † give analyses of the various gases which are evolved, together with the saline waters and petroleum, from the springs of Salsomaggiore. The gases, which burn with a luminosity about equal to that of ordinary coal-gas, consist for the most part of methane and ethane, with varying and, in general, small proportions of unsaturated hydrocarbons, nitrogen and carbon dioxide.

Natural Gas in the United States.—The annual report of the United States Geological Survey on the production and consumption of natural gas, which has just been compiled by F. H. Oliphant, ‡ presents some very interesting features, inasmuch as it embraces a comprehensive survey of the gas-producing fields, a discussion of the evidence that the natural supply is rapidly becoming exhausted, and some statistics concerning the extent to which natural gas is utilised as fuel by the iron and steel industries. The total value of the natural gas produced in the United States last year was £4,004,973.

* *Journal of the Canadian Mining Institute*, vol. iii. pp. 68-89.

† *Gazzetta Chimica Italiana*, vol. xxx. i. pp. 281-296.

‡ *United States Geological Survey, Twentieth Annual Report*, Part vi. pp. 203-222.

VII.—ARTIFICIAL GAS.

The Energy in Fuel Gas.—In a recent article* the energy in various forms of fuel gas is discussed. The composition and calorific value is given as follows:—

| | Carbon Monoxide. | Hydrogen. | Incombustible. | Calories. |
|-----------------|------------------|-----------|----------------|-----------|
| Generator gas . | 23 | 10 | 67 | 28 |
| Dowson . . | 23 | 19 | 58 | 36 |
| Wilson . . | 27 | 13 | 60 | ... |

In ordinary generator gas about two-thirds of the energy of the coal is present in the gas as chemical energy, and the remaining third is present as heat, which is, however, practically lost, as the gas cannot be used in its highly heated state under ordinary circumstances. Much of this heat is also wasted in radiation. Steam is, therefore, passed into the incandescent fuel, and by its decomposition absorbs a large proportion of the otherwise wasted heat, and renders it available in the chemical energy of the resultant gas. Equally good results would be obtained if a pure supply of carbonic anhydride were available to replace the steam, and the fuel used for steam-raising would then be saved. But the ordinary products of combustion contain too much inert nitrogen for satisfactory use, and the nitrogen percentage increases to such a degree that ultimately the gas will not burn.

In a discussion on the economical utilisation of fuel, W. Kent † deals with the various forms of gaseous fuel, including blast-furnace gas, producer gas, water gas, enriched water gas, and gas made in retorts and in coke ovens. Numerous quotations and extracts from recent publications are given.

Water Gas.—J. Körting ‡ compares water gas with other combustible gases. The author first gives the composition of ordinary producer gas, and then that of the so-called "power" or mixed gas. These are stated as follows:—

* *Engineer*, vol. xc. p. 355.

† *The Mineral Industry*, vol. viii. pp. 124-157.

‡ *Zeitschrift des Vereines Deutscher Ingenieure*, vol. xlv. pp. 1301-1308, 1345-1348, with four illustrations.

The first two pages

projections on the exterior, and conical openings to the interior. Gas, air, steam, and oil may be conveyed to the interior of this blast-chamber grate through hollow journals. Its lower part is immersed in the water-seal or tank. These fire-grates are surrounded by tuyere pipes in order to keep the base of the retort cool, and are supported by friction rollers, which relieve the weight on the hollow journals, on and by which they are intermittently rotated, thus agitating and keeping open the base of the fuel charge. In the bottom of the water-seal tank is an opening through which the grates may be removed from the retort. At the top of the retort are two bell-valved conduits for receiving and delivering the solid fuels (coal and coke) to either combustion chamber. Properly arranged pipes fitted with reversing valves connect the chambers, and convey the gas and air blasts in either direction, provision being made for introducing a flue cleaner to remove carbon adhering to the gas pipes.

VIII.—COAL-MINING.

Deep Boring.—The Fourteenth Congress of Boring Engineers was held at Frankfort-on-the-Main in September 1900.* E. Naumann discussed the greatest depths attained in mining and boring, and the results obtained therefrom. J. Baszanger explained the cause of the recent rise in the price of carbon, diamond, and bort used for boring purposes. E. W. Wolski described a new friction coupling for use with boring plant. H. Gothan gave an account of a magnetic needle and clockwork arrangement for determining the dip of strata in boreholes. Other papers by E. Przibilla and by F. Steiner dealt with recent progress in the art. The committee on a standard screw gauge for casings also presented a report, referring to the thickness and dimensions of casings and the threads for tool rods.

S. Trop† describes various means of excluding water from oil wells by cement plugs and packing rings of various forms in the lining.

A. Fauck‡ briefly describes the different forms of apparatus for sinking wells, and advocates his own system of rapid but short strokes, and other improvements.

Bennett H. Brough§ describes the different instruments used for

* *Boring and Drilling*, vol. i. pp. 57-78; *Petroleum Review*, vol. iii. pp. 247, 278.

† Paper read before the Baku Technical Society; *Petroleum Review*, vol. iii. pp. 221-222.

‡ *Ibid.*, p. 74.

§ *Boring and Drilling*, vol. i. pp. 13-14.

1. General

which is completed, walled, and equipped before the excavation of the next one below is begun, the same men being employed successively in the different operations of sinking, walling, and setting the guides. The rate of progress is about 20 yards a month.

One of the most remarkable mining exhibits at the Paris Exhibition is the model of No. 5 pit of the Bruay Colliery. There are two shafts, 4·2 metres wide and 355 metres deep, 47 metres apart, equipped with machinery of the latest type. The Company is one of the most important in France, its daily output being 5900 tons from eight shafts, all of which have been sunk by the Chaudron process.

K. Hostich * describes the process of sinking a shaft at Sollenau, in Lower Austria, to reach a seam of lignite at a depth of 672 feet. Special difficulties were encountered, more particularly in traversing a bed of quicksand 22 feet in thickness at a distance of 510 feet below the surface. The method adopted was to employ a wrought-iron caisson made of plate driven into the quicksand, and then timbering.

F. H. and W. Poetsch † describe at considerable length the Poetsch system of shaft-sinking. The subject is dealt with historically, the earlier experiments and practical applications of the process being first described. Its first application in practice was at the Archibald brown coal mine near Schneidlingen. The freezing machine was set to work on July 8, 1883. By the end of September the shaft had been carried through the 13-foot bed of quicksand that had to be penetrated, and the work was completed. This piece of work incidentally showed that the freezing solution must not be made colder than -20° C. One of the valves broke when struck with a hammer, and the solution escaped. The temperature of the sand sank to -19° C., the air temperature in the shaft being then -6° . The second application of the method was made in 1884 at the Centrum colliery, near Königs-Wusterhausen, about thirty-five yards of sand, mostly quicksand, or sand of a very watery character, having to be penetrated. This too was successful. The average cost of the shaft was about £95,8s. per yard. Other places at which this process has been used are the Max No. I. colliery, near Michalkowitz in Upper Silesia; the Emilie colliery, near Hennersdorf-Finsterwalde; the Charbonnages de Houssu at Haine Saint Paul in the Belgian Province of Hennegau; and the Jessenitz mine in Mecklenburg-Schwerin. Full details are given in each case as to the difficulties that had to be overcome, and the general procedure

* *Oesterreichische Zeitschrift für Berg- und Hüttenwesen*, vol. xlviii. pp. 297-300.

† *Ibid.*, pp. 189-192, 207-212, 223-224, and 235-237, with plate.

end, so that one rope winds on while the other winds off. One rope is taken directly to the headgear, while the other is first laid over a take-up gear, consisting of a sheave placed on a carriage and of winding machinery for shifting this carriage along its track. This gear is similar to that used in the Whiting system. The disadvantage of the drum hoist is that it cannot be used for a greater depth than that for which its drum is built. On the other hand, it has the advantage that, should an accident occur to one rope, only the skip on that rope would be dropped, and not both, as would be the case in the Whiting hoist.*

Illustrations are given elsewhere† of Whiting's arrangement for winding. The rope is led round two pulleys, the arrangement being like that of a cable tramway. Each pulley is furnished with Walker's rings.

Illustrations are given ‡ of the Brucksch reversing gear as fitted to the winding engines at the Luise lignite pit, Nieder-Schönbrunn, in the Görlitz district.

Shortly before the outbreak in China the Gutehoffnungshütte at Oberhausen constructed a winding plant for a colliery in the neighbourhood of Tongschau, about thirty-seven miles from Tientsin.§ This is now illustrated and described. It is capable of winding ninety tons of coal per hour from a depth of over 560 yards.

J. Gregory|| and J. T. Stobbs describe the Koepe system of winding, which has been in use for seventeen years at the Sneyd Colliery, Burslem. A. Ehrlich¶ urges the advantages presented by the Koepe system of winding over the ordinary winding drum.

G. B. Stones** describes the hydraulic cage-loading and unloading apparatus at Cadeby Colliery. The output at present is about 1800 tons a day, and it was anticipated that this would be increased to 5000 tons a day, drawn from two shafts, when the colliery was fully developed. The cages have four decks, each carrying two corves, containing an average of 10 cwt. each. The decks are loaded and unloaded simultaneously, the top deck by manual labour, the others by

* "Hoisting Engines and Appliances." Catalogue No. 2. Fifth Edition. 1900. (Chicago and London: Fraser and Chalmers.)

† *Iron Trade Review*, August 16, 1900, p. 18.

‡ *Zeitschrift für das Berg-, Hütten- und Salinenwesen im preussischen Staate*, vol. xlviii. pp. 145-146.

§ *Stahl und Eisen*, vol. xx. p. 997, with two illustrations.

|| *Transactions of the Institution of Mining Engineers*, vol. xviii. pp. 450-457.

¶ *Zeitschrift des Vereines deutscher Ingenieure*, vol. xlv. pp. 675-680.

** *Transactions of the Institution of Mining Engineers*, vol. xviii. pp. 478-482.

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Underground Haulage.—The use of pit ponies and horse haulage is dealt with by F. Povey-Harper,* questions of feeding, shoeing, stabling, and the cost being reviewed.

J. Fox Tallis† gives a number of dimensioned drawings of twenty-seven trams used in the Welsh coalfields, and in many cases gives sections of the rails used at the collieries. A suggested design is also given as a standard. In tabular forms are given the leading dimensions and other particulars of the trams, rails, and sleepers. The ratio of tare to weight carried in the trams ranges from 23·9 to 36·5 per cent.

W. D. L. Hardie‡ describes the endless under-rope haulage at Lethbridge colliery with the aid of a plan of the workings and illustrations of the various mechanical details.

W. Smith§ describes the Priestman oil engine used for underground haulage and pumping at the Jellieston Colliery, Scotland.

Heimann|| describes the mechanical haulage in the Upper Silesian collieries. Details are given of the chain haulage at seven collieries, in which the lines varied from 400 to 1850 metres in length and the cost per ton-kilometre from 3·98 to 10·8 pfennig; of the rope haulage at seventeen collieries, in which the lines varied from 560 to 2200 metres in length and the cost per ton-kilometre from 1·96 to 14·7 pfennig; and of the locomotive haulage at three collieries, in which the lines varied from 450 to 1250 metres in length and the cost from 7·7 to 8·6 pfennig.

The various mechanical methods of haulage in use in the levels of the mines and collieries of Upper Silesia are described by Heimann.|| These include the various kinds of chain and rope traction, and also those in which electric or benzine engines are in use.

Hein's releasing appliance for rope clips is illustrated.** Sickle-shaped guard-irons depress the clip and free it from the rope.

The system of electric mine-haulage which has greatly increased the output of the Eureka collieries in the Windber district in the United States, is described by A. S. M'Allister.†† In the case of one mine, the

* *Journal of the British Society of Mining Students*, vol. xx. pp. 126-130.

† *Proceedings of the South Wales Institute of Engineers*, vol. xxii. pp. 37-63.

‡ *Transactions of the Institution of Mining Engineers*, vol. xviii. pp. 335-339, with two plates.

§ *Ibid.*, vol. xviii. pp. 396-400.

|| *Glückauf*, vol. xxxvi. pp. 449-456.

¶ *Zeitschrift für das Berg-, Hütten- und Salinenwesen im preussischen Staate*, vol. xlviii. p. 18.

** *Colliery Guardian*, vol. lxxix. p. 834.

†† *Engineering*, vol. lxx. pp. 291-293; *American Electrician*, 1900, pp. 318-320.

Electricity in Mines.—H. Louis * has published a series of articles in which details are given of various examples of the application of electricity to mining. The subjects dealt with are classified under the following heads:—(1) Lighting; (2) shot firing by electricity; (3) applications of magnetic properties; (4) electrical transmission of power; and (5) special mining machinery.

J. Libert † discusses the employment of electricity in mines at considerable length, and traces its evolution since the last Paris Exhibition. Especial reference is made to Belgian practice. The paper forms one of the reports submitted at the Congress on Mining and Metallurgy held at Paris.

S. F. Walker ‡ describes and illustrates various applications of electricity in British collieries. Hauling, coal-cutting, pumping, and lighting are described with the aid of numerous illustrations, and the generating plant is also dealt with in some detail.

S. F. Walker § discusses the problems involved in running collieries entirely by electricity from one centre, and shows the advantages of that system.

W. Müller || describes at considerable length, and with the aid of many illustrations, the electric hauling and winding machinery in use in the Ruhr district. An abridged translation has appeared. ¶

E. Schulz ** describes a portable type of electro-motor protected from dust and dirt.

A detailed description of the central electric station for light and power at the Margarethe colliery at Sölde, in Westphalia, has been published. The station supplies the village as well as the colliery. ††

Hand-Boring Machines.—Comparative experiments ‡‡ at the Reden colliery with hand-boring machines gave the following results:—

* *Mining Journal*, vol. lxx. pp. 604, 634, 664, 697, 778, 796, 825, 875, 902, 925, 941. 978.

† *Bulletin de la Société de l'Industrie Minérale* (advance proof).

‡ *Engineering Magazine*, vol. xix. pp. 713-727, 847-866.

§ *Journal of the British Society of Mining Students*, vol. xxii. pp. 116-125.

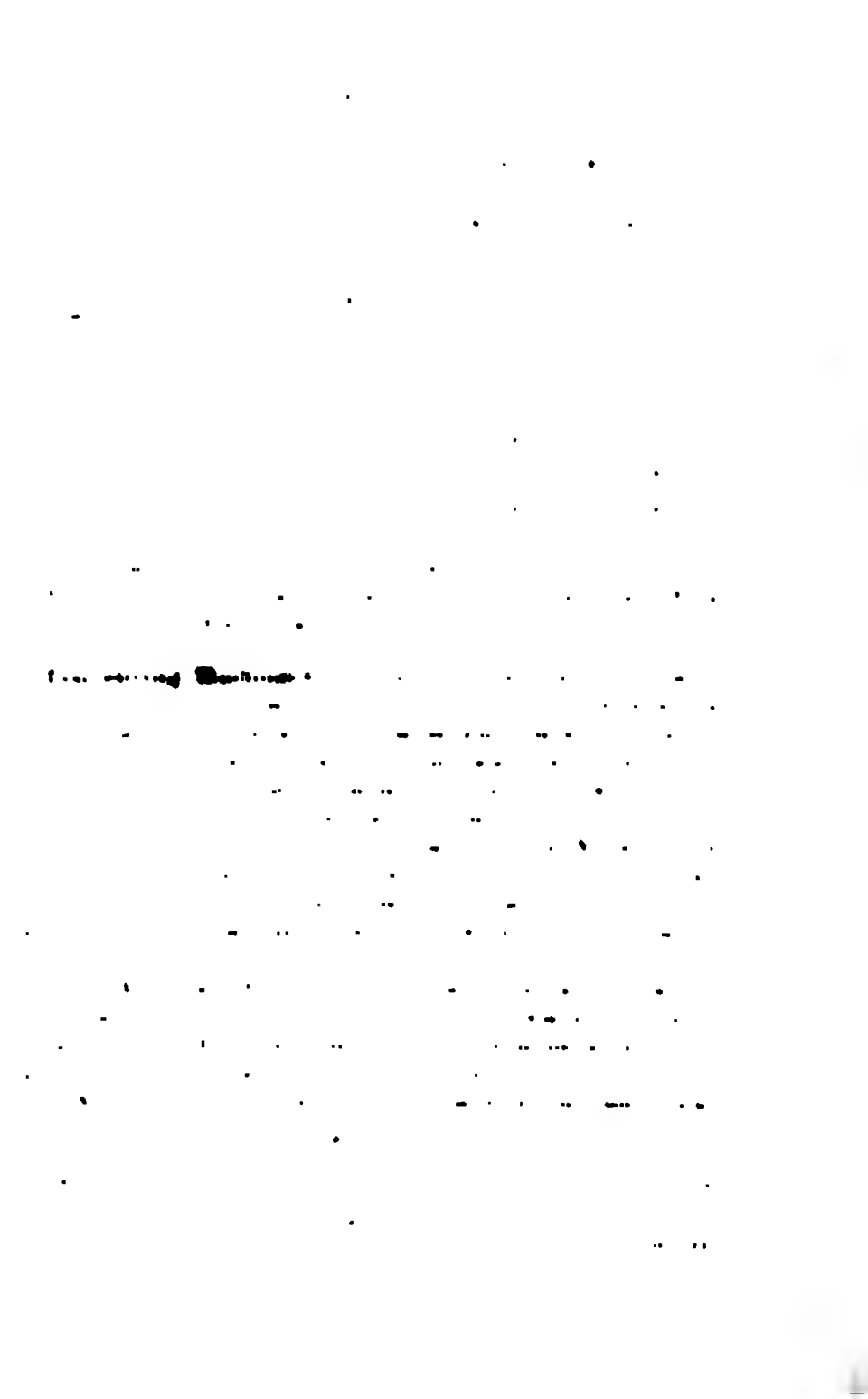
|| *Glückauf*, vol. xxxvi. pp. 341-352.

¶ *Iron and Coal Trades Review*, vol. lx. pp. 940, 1037, 1081.

** *Glückauf*, vol. xxxvi. pp. 405-406.

†† *Ibid.*, pp. 393-394.

‡‡ *Zeitschrift für das Berg-, Hütten- und Salinenwesen im preussischen Staate*, vol. xlviii. pp. 104-150.



cutting machinery in the United States. The number of machines used in 1899 was 3125, and 43,963,933 tons of coal were produced, an increase of about $11\frac{1}{2}$ million tons over the previous year.

Timbering in Mines.—J. Dickinson * discusses the question of pit props and their setting, showing that the length of a prop does not affect its strength within the usual limits of ratio of diameter to length, and that divided opinions are still held as to the direction or angle at which props should be set. The supply of timber and the use of tubular steel props are also referred to and discussed.

The Balmer pit prop consists of two cast iron cylinders, of which the lower is filled with loose packing and the upper part telescopes into it. Holes in the side of the lower cylinder allow some of the packing to be removed, so that the prop can shorten itself.†

S. J. Bridges ‡ gives some particulars showing the advantages of Hepplewhite's tapered props.

The methods of timbering in use at the Courrières collieries near Lens are described and illustrated.§ Each worker at a face has a number of iron bars $1\frac{3}{8}$ inch square and $4\frac{1}{4}$ feet long, which he uses as roof bars, and keeps them in advance of the last set of props.

Mine timbering in Germany is discussed by F. H. Probert,|| especially in view of Californian practice.

W. E. Sanders ¶ describes the methods of timbering used in the Western United States, chiefly in shafts and working places of metal mines.

O. Chanute ** gives details of the present practice of preserving timber, chiefly as applied to railway sleepers.

David J. Evans,†† in a paper read before the Indiana Mining Institute, describes various ways of cutting and placing timbers to secure the best results.

Explosives and Blasting.—At the Paris International Congress on mining and metallurgy several papers in connection with explosives

* *Transactions of the Manchester Geological Society*, vol. xxvi. pp. 476-484.

† *Transactions of the Institution of Mining Engineers*, vol. xviii. pp. 431-432.

‡ *Iron and Coal Trades Review*, vol. lxi. p. 835.

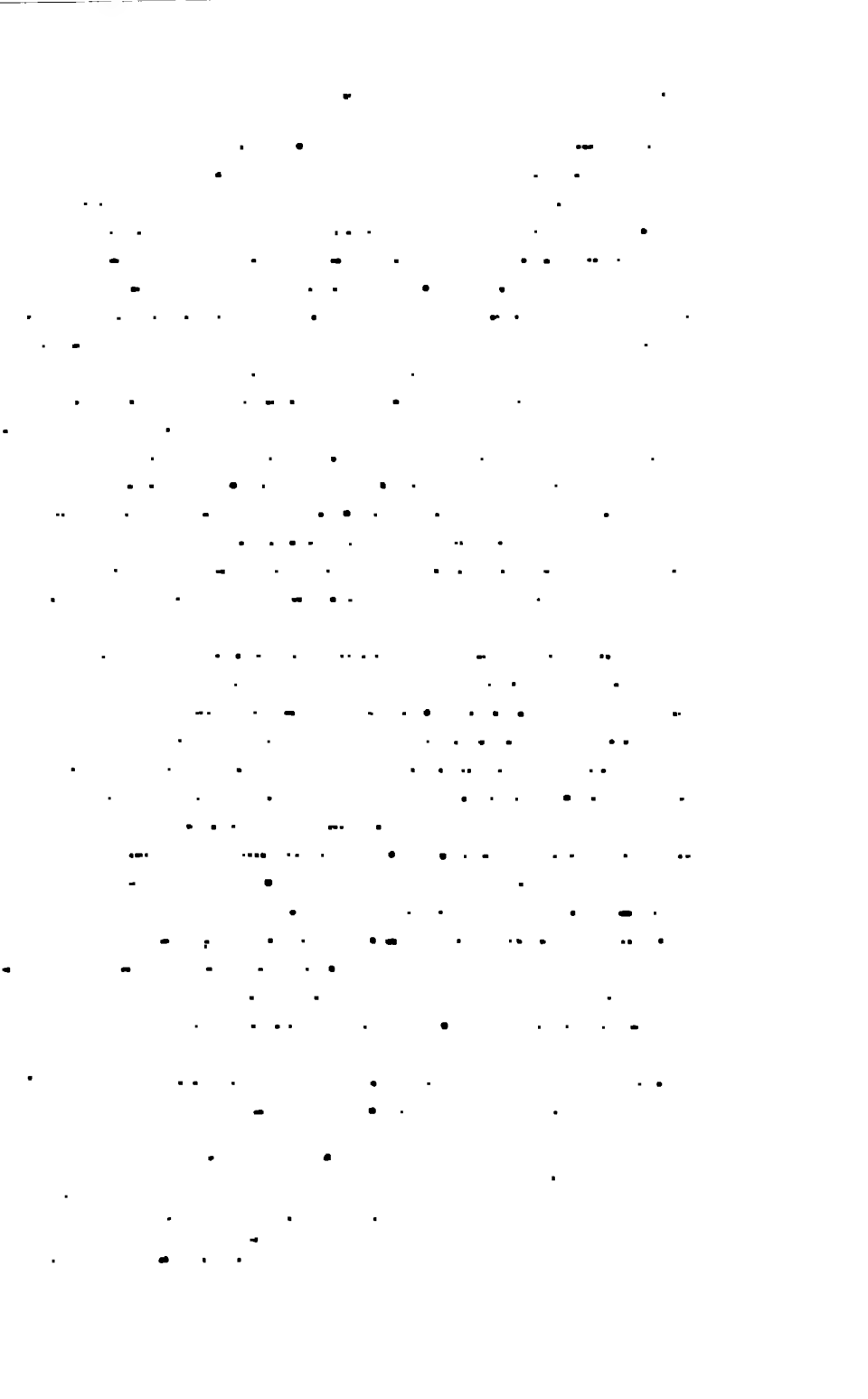
§ *Ibid.*, vol. lxi. pp. 571-572.

|| *Transactions of the American Institute of Mining Engineers*, Washington meeting, 1900.

¶ *The Mineral Industry*, vol. viii. pp. 715-743.

** *Journal of the Western Society of Engineers*, vol. v. pp. 100-126.

†† *Mines and Minerals*, vol. xxi. pp. 39-40.



French Commission on this subject. The subject is dealt with fully, and it is shown that it is undesirable to allow a magazine under ground to contain more than 2 cwt. of explosives. These are to have two open-work doors to allow of ventilation, and are to be well out of the way of any possible interference with the ventilation should an explosion result.

A memoir by R. Mewes * on the efficacy of explosives is published.

The Meinhard percussion igniter is an arrangement by which it is intended to avoid danger in fiery mines, in which fuses can still be used, from the explosion of the detonator used to ignite the fuse. A tube is employed that can be placed over the detonator. In this tube is a spring surrounding a sort of piston rod. When a ring outside the apparatus is pulled and then let go, this rod is forced back by the spring against the detonator, and explodes this inside the tube. Smoke issuing through holes in the tube shows if the fuse has fired properly. The apparatus is of very small dimensions, being only about $7\frac{1}{2}$ inches in length, and can readily be put in the pocket, with, say, 100 detonators. These are covered with wax to render them water-tight in the mine, and, packed in boxes, do not take up more space than would a watch. The fuse requires no preparation.†

A description has been published ‡ of a French device by which a fuse may be safely fired in a fiery mine.

Methods of Working Coal.—At the Paris International Congress of Mining and Metallurgy three long papers were included on the conditions of mining at great depths. They were by L. Poussigue,§ S. Stassart,|| and J. Hrabak.¶ Of these, the second by S. Stassart dealt more particularly with Belgian practice, and considers in detail the arrangements of five of the deepest collieries in that country. The increase of temperature involves greatly increased ventilation, and at the same time the air must be dry. Winding may be done at depths to 1630 yards in one lift with moderate loads at high speeds, but the author is strongly in favour of the flat aloof-fibre rope in preference to wire ropes. Pumping, ventilation, and cooling the air are also considered.

* *Dingler's Polytechnisches Journal*, vol. cccxv. pp. 408-412.

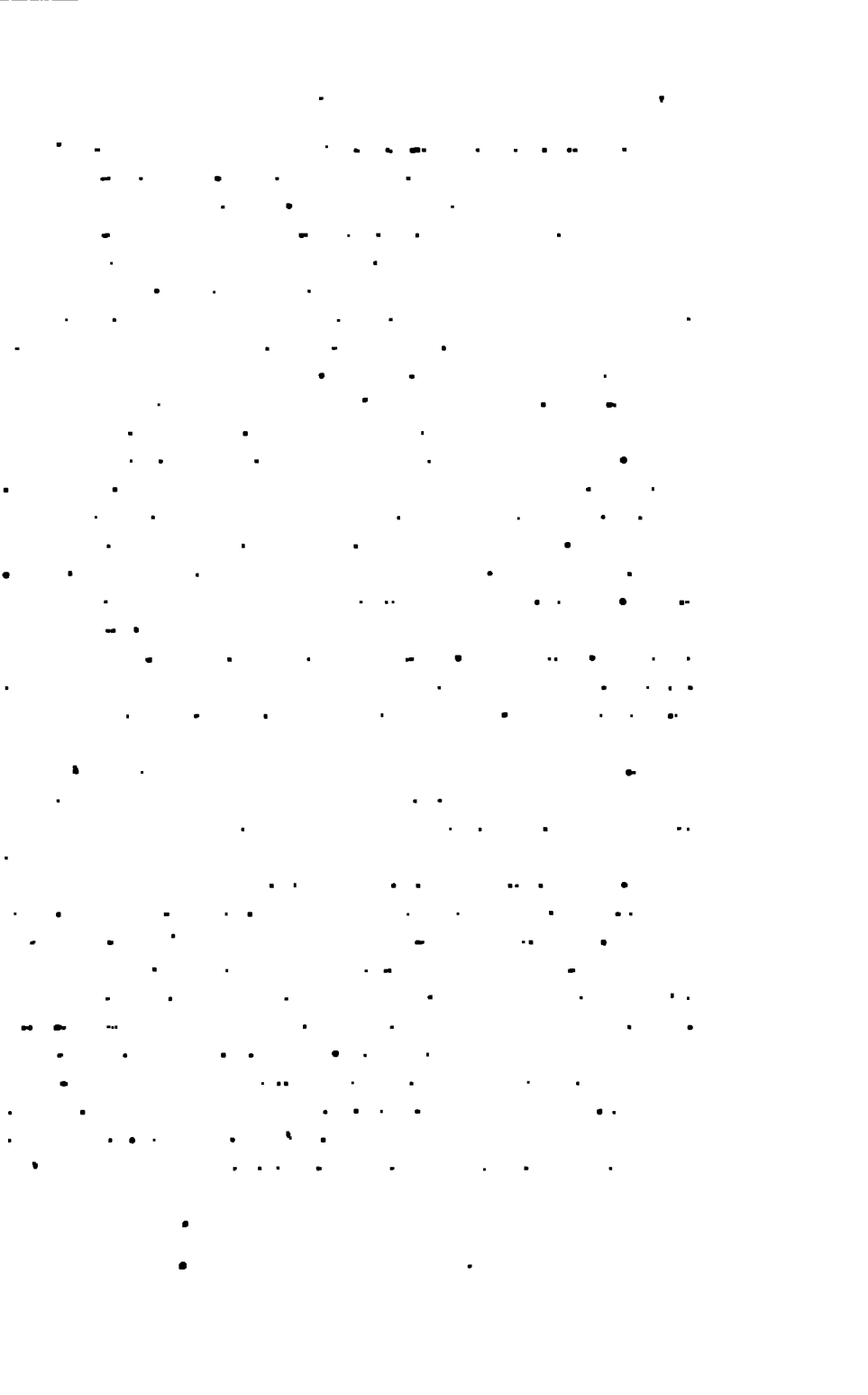
† *Oesterreichische Zeitschrift für Berg- und Hüttenwesen*, vol. xlviii. pp. 197-198, with an illustration.

‡ *Mines and Minerals*, vol. xx. p. 539.

§ *Bulletin de la Société de l'Industrie Minérale*, vol. xiv. pp. 193-374.

|| *Ibid.*, pp. 375-479.

¶ *Ibid.*, pp. 135-192.



features attending the withdrawal of ribs and pillars in colliery workings. Some forty points are considered, and the author advocates machine-cutting.

J. T. Baird * describes the various systems of working coal adopted in Iowa; long-wall, pillar-and-stall, double stall, and panel breasts are all used.

G. E. Harris † describes the Makum coalfield in Assam, and gives some details of the method of working adopted, which resembles the South Staffordshire square work. Sides of work, 30 by 40 yards, are set off and pillared in the lower part, after which the upper part is dropped by thinning and removing the pillars.

Watteyne ‡ discusses the prevention of accidents in the shoots or passes used for delivering coal in inclined seams.

Mine Drainage.—Henry Davey § has written an exhaustive work, in which he divides his subject-matter into fifteen chapters, dealing respectively with the early history of the pumping engine, steam pumping engines, pumps, and pump valves, the general principles of non-rotative pumping engines, the Cornish engine, simple and compound types of mining engines, pitwork, shaft sinking through water-bearing strata, hydraulic transmission of power in mines, valve gears of pumping engines, water pressure pumping engines, waterworks engines, pumping engine economy and trials of pumping machinery, centrifugal and other low-lift pumps, and hydraulic rams. Electric pumps are not dealt with. Electricity, the author points out, is coming into use as a medium of transmission of power to underground pumps, but up to the present time it has not been largely used except for small powers. The chief difficulty has been in the application of the quick-running motor to the slow-running pump, an operation involving high-speed gearing, belts, or ropes, all of which are practically objectionable. Attempts are being made to produce a quick-running pump and a slow-running motor in order to minimise the gearing required. It is in this direction that improvements must be made if electricity is to be applied to heavy pumping.

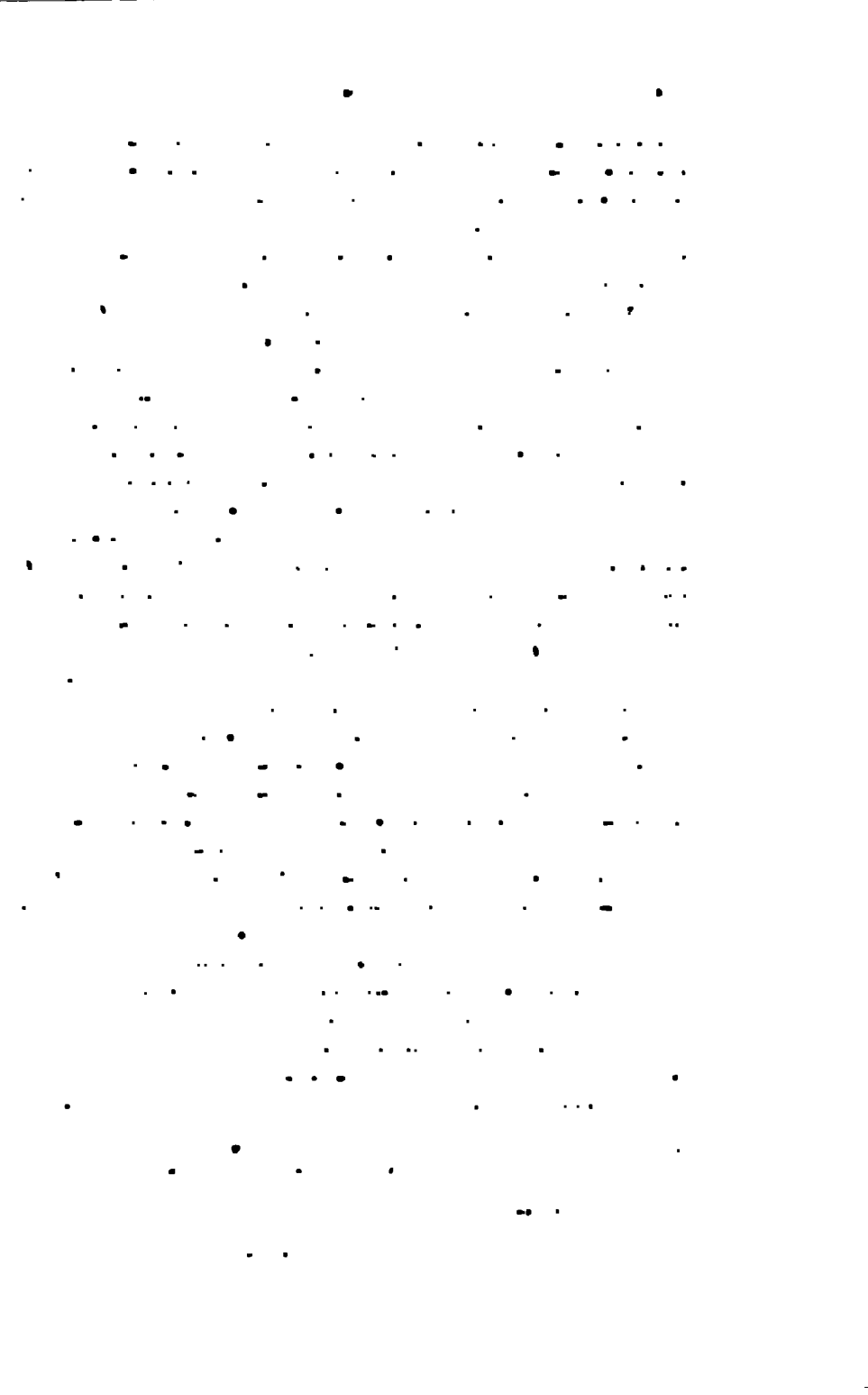
The old Cornish engine with its pitwork has been superseded by improved types of pumping machinery. Long experience has, however, shown the value of working with engines that have a distinct

* *Mines and Minerals*, vol. xxi. pp. 126-127.

† *Transactions of the Manchester Geological Society*, vol. xxvi. pp. 572-590.

‡ *Annales des Mines de Belgique*, 1900, No. I.

§ *The Principles, Construction, and Application of Pumping Machinery*.



which has been at work for eight months, presents many points of novelty.

C. François* describes the Kaselowsky pumping-engine at West-phalian collieries.

H. Schmerber† describes the construction of a subterranean drainage level which is to connect the lignite mines of Gardanne, near Marseilles, with the sea. The paper gives a long and well-illustrated account of methods of construction and apparatus employed.

C. Cooke‡ gives some notes on the reopening of a flooded colliery in the Lancashire coalfield. The colliery had been worked on bad lines in the middle of the century, but was recovered about 1874 with some difficulty, due to the extensive caving and the large amount of water. After a short period the colliery was again drowned, and extensive pumping operations, followed by re-sinking under many difficulties, were again successful, but only for a year, when the water again broke it. The various operations are sketched in some detail.

The Ventilation of Collieries.—In his monograph on the conditions of mining at great depths, contributed to the Congress on Mining and Metallurgy at Paris, L. Poussigues§ discusses the problems of ventilation at considerable length, and *inter alia* refers to the use of Ser and of Mortier fans running in series.

At that Congress Paul Petit|| discussed the resistance opposed to air currents by regulating doors.

Comparative tests of a Rateau and a Guibal fan, under the same conditions, have been made by A. Soupart and L. Legrand of the Charbonnages Réunis de Charleroi,¶ and a table recording the results of the experiments is given. A mean of the four observations made on each of the two fans shows that the Rateau has a mean mechanical yield of 0·635, and the Guibal one of 0·445, the difference in favour of the Rateau being 0·19.

An illustration is given** of the Mortier fan at the Bruay colliery.

H. W. Halbaum†† discusses the practicable scope or the limits

* *Revue Universelle des Mines*, vol. xlvii. pp. 152-164.

† *Génie Civil*, vol. xxxvii. pp. 57-60, 100-102.

‡ *Journal of the British Society of Mining Students*, vol. xx. pp. 147-155.

§ *Bulletin de la Société de l'Industrie Minière*, vol. xiv. pp. 193-373.

|| *Ibid.*, vol. xiv. pp. 481-949.

¶ *Revue Universelle des Mines*, vol. l. pp. 44-51.

** *Colliery Guardian*, vol. lxxx. p. 424.

†† *Ibid.*, vol. lxxx. pp. 315-317.

gives elsewhere * a description of the mine and conditions existing before the accident.

The Lighting of Collieries.—Some illustrations of various forms of modern and other safety lamps have appeared.†

J. G. Patterson ‡ describes Howat's latest form of safety lamp, the Patterson gauze, and the Darrah-Patterson electric igniter.

J. Ashworth § deals with the failures of safety lamps while in use, and some of the disasters caused thereby. Especial attention is given to the risk of explosion in air containing fire-damp and dust in suspension.

An account is published by Fillunger || of an explosion, which was fortunately of a very slight character, and was apparently due to the internal percussion-igniting arrangement in the lamp, which was of the Wolf benzine type. The author considers that other explosions have been due to the same cause.

In the discussion which ensued on the reading of this paper Pospisil mentioned a similar case. In this instance the lamp had gone out, and there was apparently no gas in the level at this point. On re-lighting the lamp by the percussion attachment, a slight explosion of gas took place within the lamp, and at one part of the gauze a flame appeared radially around the lamp for a distance of about an inch. This appearance of flame was merely momentary. The author shortly afterwards went back to the same spot and tried to repeat this, but failed to do so. He has since seen a similar experience described by J. Ashworth and A. R. Sawyer. Dust, he thinks, has much to do with such explosions.¶

Fähndrich ** describes the testing station for safety lamps and the experimental mine gallery at Bismarck, in Westphalia. The paper is accompanied by dimensioned drawings of the lamp-testing apparatus employed.

The electric lamp designed by Gülcher †† for use in collieries gives

* *Mines and Minerals*, vol. xx. pp. 537-539.

† *Iron and Coal Trades Review*, vol. lx. p. 1231, vol. lxi. p. 13.

‡ *Transactions of the Manchester Geological Society*, vol. xxvi. pp. 362, 427; *Transactions of the Institution of Mining Engineers*, vol. xix. pp. 42-47.

§ *Ibid.*, vol. xxvi. pp. 519-551.

|| Paper read before the Mining and Metallurgical Society of Moravian-Ostrau.

¶ *Oesterreichische Zeitschrift für Berg- und Hüttenwesen*, vol. xlviii.; *Beilage*, pp. 31-33.

** *Glückauf*, vol. xxxvi. pp. 445-449.

†† *Oesterreichische Zeitschrift für Berg- und Hüttenwesen*, vol. xlviii. p. 450.

Section 1: The First Chapter

Section 2: The Second Chapter

Section 3: The Third Chapter

Section 4: The Fourth Chapter

Section 5: The Fifth Chapter

Section 6: The Sixth Chapter

Section 7: The Seventh Chapter

Section 8: The Eighth Chapter

Section 9: The Ninth Chapter

Section 10: The Tenth Chapter

Section 11: The Eleventh Chapter

Section 12: The Twelfth Chapter

Section 13: The Thirteenth Chapter

Section 14: The Fourteenth Chapter

Section 15: The Fifteenth Chapter

Section 16: The Sixteenth Chapter

Section 17: The Seventeenth Chapter

Section 18: The Eighteenth Chapter

K. Müller* describes what he believes to be the first steam-engine ever used in the brown coal mines of North-West Bohemia. It was erected near Udwitz in 1813.

At a meeting of the Western Pennsylvania Central Mining Institute, F. C. Keighly read a paper on bituminous coal-mining, in which he showed that the first discovery of coal in America was made by Father Hennepin in 1669 in Illinois. The city of Pittsburg was laid out in 1764, and twenty years later the privilege of mining coal was granted by William Penn. Anthracite was discovered in 1768.

Mine Surveying.—A beam compass with a scale and vernier attachment is described by C. Gregorie† for plotting surveys. By its aid measurements of one link and less can be plotted on plans of two chain and $\frac{1}{1000}$ scale.

L. C. Morganroth‡ discusses the methods of preparing and keeping maps of collieries, both of the surface and of the underground workings.

A. Rost§ has described the theodolites and other surveying instruments for use in mines which have been made by the firm of R. & A. Rost for the Paris Exhibition.

In order to obviate the errors in measuring lengths in mine surveys caused by variations in the tension of steel measuring-bands, M. Przyborski|| has devised an ingenious instrument, consisting chiefly of a spiral spring, which, placed at the end of the steel band, enables the tension to be regulated.

Two modifications in the adjustment of theodolites for use in mines are described and illustrated by W. Breithaupt.¶

D. R. Scott** deals exhaustively with the development of mine surveying instruments; O. Brathuhn†† describes Langer's patent hanging compass; and F. H. Newell‡‡ describes the hydrographic investigations of the United States Geological Survey in their relation to mining.

* *Oesterreichische Zeitschrift für Berg- und Hüttenwesen*, vol. xlviii. pp. 203-205, with two illustrations.

† *Proceedings of the South Wales Institute of Engineers*, vol. xxi. pp. 527-530.

‡ *Engineering and Mining Journal*, vol. lxx. pp. 367-368.

§ *Oesterreichische Zeitschrift für Berg- und Hüttenwesen*, vol. xlviii., *Beilage*, pp. 45-48, with five illustrations.

|| *Ibid.*, p. 309.

¶ *Ibid.*, vol. xlviii. p. 451, with two illustrations.

** *Transactions of the American Institute of Mining Engineers*, vol. xxviii. p. 673, vol. xxix. p. 931.

†† *Zeitschrift für Vermessungswesen*, 1900, p. 186.

‡‡ *Transactions of the American Institute of Mining Engineers*, February 1900.

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James M. Smith, Jr., President, American Society of
 Zoologists, Inc., 1960-1961

Glencraig (vol. lxxix. p. 932). The collieries in the Lanarkshire coalfield described are:—Viewpark colliery (vol. lxxix. p. 979); Holytown colliery (p. 1025); Allanton colliery (p. 1078); Orbiston colliery (p. 1126); Dalzell and Broomside colliery (p. 1172); Rimmon, Calderhead, and Hartwood Hill collieries (p. 1219); Auchlochan colliery (vol. lxxx. p. 14); Shields colliery (p. 113). An illustrated description of the collieries of the Ebbw Vale Company has appeared.*

H. F. Bulman describes the following collieries:—Metropolitan in New South Wales (*Colliery Guardian*, vol. lxxix. p. 879); and the Aberdare Colliery, near Ipswich, in Queensland (p. 1123).

According to J. Jičinsky,† the Königin Luise Colliery, in Moravian-Ostrau, is worked by the State, and possesses seven winding shafts. Employment was given in 1899 to 7850 workpeople, and the output reached 2,956,995 tons of coal, valued at £1,095,000. One of the seams is 26 feet in thickness. The main working faces are lit by electric arc lamps. The method of working is described.

The Concordia Colliery has only one winding shaft, but the quantity wound through this one shaft is probably larger than through any other one shaft on the Continent of Europe, about a million tons having been raised in 1899. The pumps, fans, and other appliances are described.

J. Crankshaw ‡ gives some general notes on coal-mining in South Russia.

H. M. Cadell§ describes a colliery in the Karharbari coalfield, and describes the miners and their work in some detail.

A short description of the collieries at Kebao, Tonking, has appeared.||

IX.—COAL-WASHING.

Coal-Washing and Screening.—One of the course of lectures on mining recently published by Professor W. Galloway ¶ deal with the washing and screening of coal. A plan of the plant at the Nouvelle Marihay collieries is given, and the process adopted there is described with the aid of illustrations of the machinery, and of some other forms

* *Iron and Coal Trades Review*, vol. lxi. pp. 169-172.

† *Oesterreichische Zeitschrift für Berg- und Hüttenwesen*, vol. xlviii., Beilage, pp. 80-81.

‡ *Transactions of the Manchester Geological Society*, vol. xxvi. pp. 410-419.

§ *Transactions of the Institution of Mining Engineers*, vol. xix. pp. 60-68.

|| *Iron and Coal Trades Review*, vol. lxi. p. 217.

¶ *Proceedings of the South Wales Institute of Engineers*, vol. xxi., Appendix.

of analogous machinery used elsewhere. Revolving tipplers, the screens of Briart, Coxe, Humboldt, Borgman-Emde, Karlick, and shaking screens, revolving screens, and various forms of picking bands are first considered, and then attention is directed to appliances used for washing nuts and fine coal.

W. W. Beaumont* describes the vibromotor and its application to screening coal, giving illustrations of several forms in use. An arrangement of screen, driven by gearing and a flat-jointed rod, is made by the Hardy Patent Pick Company for screening coals, minerals, and other materials. A heavier form of vibromotor screen, as made by the same firm, for giving three different sizes of coal at the rate of about 350 tons per day, is used at the Low Moor and other collieries, and by Messrs. Cory & Sons, and a somewhat similar screen, giving five sizes of screen product, is shown in connection with a set of plant for crushing materials before screening, and for re-elevating the tailings to the screen after passing through a second crusher for further reduction in size. This arrangement secures a regular delivery of the material to the receiving end of the screen. Regular delivery by such means, or from hoppers or a vibrating shoot, should be insisted upon wherever possible, as this promotes the regular action of the screen and the better treatment of the materials acted upon. Coal screens of this kind are generally made in sizes up to 12 feet by 4 feet, with perforated screening plates, with holes from $\frac{1}{4}$ inch to $2\frac{1}{2}$ inches and for giving five products: that is to say, for dust, slack, peas, nuts, and cobbles. Larger screens have been made. Those which are 12 feet by 4 feet will do from 200 to 300 tons per day with about $3\frac{1}{2}$ to 4 horse-power, and according to the size of coal to be screened. Rope-driving is used in some cases, but belt-driving is preferred; belts of only about 3 inches wide being used for these large screens. The whole of the work done being utilised in the required result, very small power is used. The diameter of the gyratory circle described by these screens of the larger sizes for coal is generally not more than an inch, and the number of revolutions of the vibromotor spindle about 350 per minute. These figures, of course, vary with the screens of different sizes and for different purposes.

A plan of the new plant at Broomhill Colliery is given by J. E. O'Keefe† to show the banking and screening arrangements to deal with 1800 tons daily.

* *Journal of the British Society of Mining Students*, vol. xx. pp. 105-115.

† *Ibid.* pp. 131-133.

An illustration has appeared * of two 400-ton Robinson washers erected in Alabama.

The coal-washing plant of the Dominion Coal Company in Nova Scotia, recently visited by the American Institute of Mining Engineers, consists of two Robinson-Ramsay coal-washers, with a combined capacity of 2000 tons of washed coal per day. The slack coal, deposited in bins with a storage capacity of 1200 tons, is raised to the top of the building and divided between the two washers. An average of 41 per cent. of the ash and 28 per cent. of the sulphur is removed by the washing. Coming from the washers, the coal is carried over screens, and the water drained into tanks, whence it is pumped by four pulsometers of 1000 gallons capacity per minute, and used over and over again. After passing over the screens the coal falls into another elevator that takes it to the washed coal storage bin, holding 1800 tons.†

A description has appeared ‡ of the surface arrangements and screening plant of the Gilly colliery near Charleroi in Belgium, where 152,800 tons were wound in the year in two shafts. Cox's gyratory screens are in use.

Illustrations are given § of the coal separating plant at the Königin Luise colliery. The coal from the pit is classified by the main plant into lumps, two grades of nuts, and smalls, the first three kinds being delivered on to picking bands and conveyors, whilst the smalls fall into a hopper, whence they are discharged through a shoot on to the endless belt which delivers them to the swinging screen on the way to the railway trucks. If it is desired to pass them through the secondary classifiers a shoot is closed by a shutter, and the coals fall on to the sloping screen, which is provided with a double bottom, the upper floor of which consists of perforated sheet metal of $\frac{3}{4}$ -inch mesh, the lower floor being unperforated. The bulk of the dust coal drops through the meshes on to the lower floor, whence it falls through a shoot on to the conveyor. The screen is caused to swing by means of eccentrics. The smalls from the upper floor of the screen fall into a bin and are raised by an elevator to a Baum swinging screen, where they are classified into nuts I. and II., peas, and lump.

* *American Manufacturer*, vol. lxi. p. 277.

† *Canadian Mining Review*, vol. xix. p. 198.

‡ *Annales des Mines de Belgique*; *Colliery Guardian*, vol. lxxix. pp. 1186-1187.

§ *Zeitschrift für das Berg-, Hütten- und Salinenwesen im preussischen Staate*, vol. xlviii. pp. 109-111.

opportunity for the introduction of special machinery to utilise the immense tracts of peat land extending all over Russia. This question is being taken up by the Government. Commissions were appointed to consider the question, and have submitted a report on the subject embodying important suggestions as to the manner of bringing this simple industry before the peasantry of the country, and also suggesting that financial assistance should be granted by the Government for the purchase of the necessary machinery for the construction of narrow gauge railways, &c.

Handling Coal.—Illustrations are given * of the Temperley transporter erected at the Viscaya works, Bilbao, for discharging coal from vessels and piling it. The overhang on the water side is 43 feet, and on the land side 100 feet. Loads of 30 cwt. are handled with a hoisting speed of 300 feet, and a traversing speed of 600 to 800 feet per minute.

In a paper read before the *Verein Deutscher Eisenhüttenleute*, Aumund† considers the subject of transporting coal, and of charging and discharging it in transport. He deals with the Hunt appliance, which he describes in detail. Illustrations of this elevator are shown in connection with German works. Mention is made of a ship carrying 2300 tons of coal that was filled by two of these elevators in twenty-four hours. One of the illustrations shows this elevator as employed at Copenhagen in loading ships belonging to the Danish Coal Company. At Copenhagen alone there are employed thirteen of these elevators, and seventy-five automatic lines in connection with them. The subject is dealt with at considerable length.

Illustrations are given ‡ of a wire ropeway for handling coal at San Francisco.

Some illustrations of belt conveyors for handling coal have appeared.§

S. A. Everett || describes the surface arrangements for the delivery of coal from pit cage into railway waggons for a quantity of say 1500 tons per day, exclusive of coal-washing and coking.

* *Iron and Coal Trades Review*, vol. lxi. pp. 727-730.

† *Stahl und Eisen*, vol. xx. pp. 825-836, with 11 illustrations.

‡ *Engineering and Mining Journal*, vol. lxx. p. 163.

§ *Iron and Coal Trades Review*, vol. lxi. pp. 780-782.

|| *Proceedings of the South Wales Institute of Engineers*, vol. xxi. pp. 386-451.
Canadian Mining Review, vol. xix. pp. 154-160.



PRODUCTION OF PIG IRON.

CONTENTS.

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I.—BLAST-FURNACE PRACTICE.

A New English Blast-Furnace.—A. Sahlin* describes the reconstructed blast-furnace at Askam, belonging to the Millom and Askam Hæmatite Iron Company. The present plant consists of six furnaces 70 by 19½ feet at Millom, and four at Askam, 75 by 19½ feet. Of these, six at present are in blast, making 130 tons each daily of Bessemer pig iron.

The new furnace stack is 90 feet high, the steel shell being built of sufficient size to admit of a 20-foot bosh. The present lining will be built to a bosh diameter of 18 feet. The hearth measures 11 feet in diameter at the tuyere line, and is fitted with twelve 5-inch tuyeres placed 8 feet above the hearth level. Two slag notches are provided at opposite sides of the furnace. The tap-hole is closed by a mechanical stopper worked by compressed air. The hearth is bound with cast iron coil plates 3½ inches thick and 8 feet high. The phosphor bronze tuyere coolers are supported by a belt of 12 cast-steel collars strongly bolted together. The bosh is bound with five 9-inch by 1-inch steel hoops, and is cooled by 11 rows of cast-copper cooling plates. The shell is supported by six columns 26 feet high, resting on a solid iron base 18 inches high, and leaving the bosh and lower part of the shaft accessible. The stock line at top measures 14 feet in diameter, and is protected by iron plates built into the furnace wall. The

* *Iron and Coal Trades Review*, vol. lx. pp. 1229-1230; *Iron Age*, July 12, 1900, pp. 14-15.

1. The first step is to identify the key components of the system. This includes understanding the hardware, software, and data involved.

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^a The number of subjects who were included in each group was as follows: 10 in the control group; 9 in the low-dose group; 8 in the medium-dose group; 7 in the high-dose group.

1. *Journal of the American Medical Association*, 1990; 263: 1025-1026.

1. *Chlorophyll a* and *Chlorophyll b* were determined by the method of Arar and Collins (1971) using a Shimadzu 1010 spectrophotometer. The concentration of chlorophyll was expressed as $\mu\text{g mL}^{-1}$ of the sample.

1. *Journal of the American Medical Association*, 1997; 278: 1039-1044.

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Journal of Management Education 30(6)p. 789-804
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1. *Journal of the American Medical Association*, 1997; 277: 1033-1036.

of the *Journal of the American Medical Association* (JAMA) and the *New England Journal of Medicine* (NEJM) are the most widely cited journals in the field of medicine. The *JAMA* is a weekly journal that publishes research, clinical practice, and medical news. The *NEJM* is a weekly journal that publishes research, clinical practice, and medical news. Both journals are published by the American Medical Association (AMA).

Section 1 - Identification of Student Performance Goals

[illegible]

faultless for the protection of blast-furnace boshes and hearths, but very little attention is paid to the protection of the lining above the mantle. Some furnacemen use mantle-plates, while others do not; but to preserve the lines of the furnace, and thereby to prolong its life, something should be done. The Buffalo furnace, as put in blast in 1895, had three rows of double pipe cast-iron plates of the ordinary type above the mantle. The first row of these plates was placed 5 inches above the mantle, with the front edge of each plate $4\frac{1}{2}$ inches from the inside line of the brickwork; the second row was $2\frac{1}{2}$ feet above the first, with the front edge of each plate 9 inches from the inside line of the brickwork; and the third row was $2\frac{1}{2}$ feet above the second, with the front edge of each plate $4\frac{1}{2}$ inches from the inside line of the brickwork. After blowing-in, the furnace worked very well for the greater part of the first year, when it began hanging and slipping, which gradually became so pronounced as to interfere materially with the grade of the iron. About the end of the first year, the water circulation was lost on the inner pipes of the three rows of plates above described; after which there was no more hanging and slipping, while the grade of the iron improved and the output increased. In about a year and a half from the time the inner rows of pipes were lost, the outer rows were lost also; and there being no water protection left, the furnace soon enlarged at this point to such an unfavourable diameter and shape that it became necessary to blow out at the end of the third year.

The ledge formed by the wearing away of the brickwork above the plates interferes with the regular descent, and when the pipes are lost the lining naturally wears away. This could be sufficiently retarded to ensure the retention of favourable lines, through the period of an average blast, by six rows of plates above the mantle, placed $2\frac{1}{2}$ feet apart, with their front edges at least 9 inches from the inside line of the brickwork.

The author has also observed the result of fitting up a furnace with rows of solid cast-iron plates at the stock-line, and finds that these plates, with an inner edge 5 inches wide, placed in rows 1 foot apart, have worn well, and have protected the lining at this point. It would not be surprising to see, before long, furnace stocks plated from the mantle to a point above the stock-line with water-plates and solid plates. The only question difficult to decide will probably be the point in the ascent at which the water-plates should stop and the solid plates begin.

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and in the latter 232 lbs. of dust. The appliance consists of a rectangular box, about 16 feet square, with a funnel-shaped bottom. A layer of iron scale, about 4 feet in thickness, is suspended in the centre, to act as a filtering material, and is arranged so that it can be shaken at intervals to allow the dust to fall through. The apparatus is also described by E. Demenge.*

Charging Blast-Furnaces Mechanically.—F. W. Lürmann † makes suggestions as to the mechanical charging of blast-furnaces. Referring to the inclined hoist of the Brown Hoisting and Conveying Machine Company of Cleveland, the author observes that by its use labour is saved; but these hoists are fixed, and there is one for every blast-furnace. If, therefore, anything should go wrong with one of these hoists, the blast-furnace it serves would have to go out of work while repairs were being made to the hoist. He suggests, therefore, that a hoist should be movable, like a travelling crane, and gives explanatory illustrations.

A. E. Maccoun ‡ states that an electrically driven hoist was started in 1898 at one of the Edgar-Thompson furnaces, and since then six more have been added. Tests show an average efficiency of 61 per cent., though the load raised varies from 1 to 5 tons. Their advantages as compared with steam-hoists are discussed.

Illustrations have appeared § of a hoist designed by E. G. Rust for blast-furnaces. A double track is provided on an inclined girder, one track being over the other, so that the skips running on them counter-balance each other but run to the same loading and discharging points.

An illustrated description has been published ¶ of the new Otto wire ropeway constructed for the Hoesch Ironworks at Dortmund. The line is 1160 feet long, the difference in level between the loading and discharging stations being $81\frac{1}{2}$ feet, and the maximum gradient 1 in 8.4. The capacity of the line is 20 tons an hour. It is intended for the transport of coke to the blast-furnaces, and connects the coke-ovens with the blast-furnace plant.

Blowing-Engines.—Illustrations of a blowing-engine for an iron-works in Ohio have appeared ¶¶ It is of the steeple type, with air

* *Bulletin de la Société Industrielle de l'Est*, 1899-1900.

† *Stahl und Eisen*, vol. xx. pp. 561-564, with illustrations.

‡ *Iron Age*, June 28, 1900, p. 34.

§ *Ibid.*, September 6, 1900, pp. 10-11.

¶ *Stahl und Eisen*, vol. xx. pp. 981-982.

¶¶ *American Manufacturer*, vol. lxvii. p. 446; *Iron Age*, June 7, 1900, pp. 10-12.

operated by hand, though at first their operation was automatic. Smaller hydraulic rams return the main rams. The cost is given at 1½d. per ton. The author also deals with the advantages of machine breakers, and the discussion turns to some extent on the sand question.

Pig Iron Casting Appliance.—K. Orth has designed a pig iron casting machine in which a number of moulds are placed longitudinally and in rows. Their movements are automatic, and can be regulated from one spot, both for filling, emptying, and subsequent transport. A description and illustrations of this appliance has appeared.*

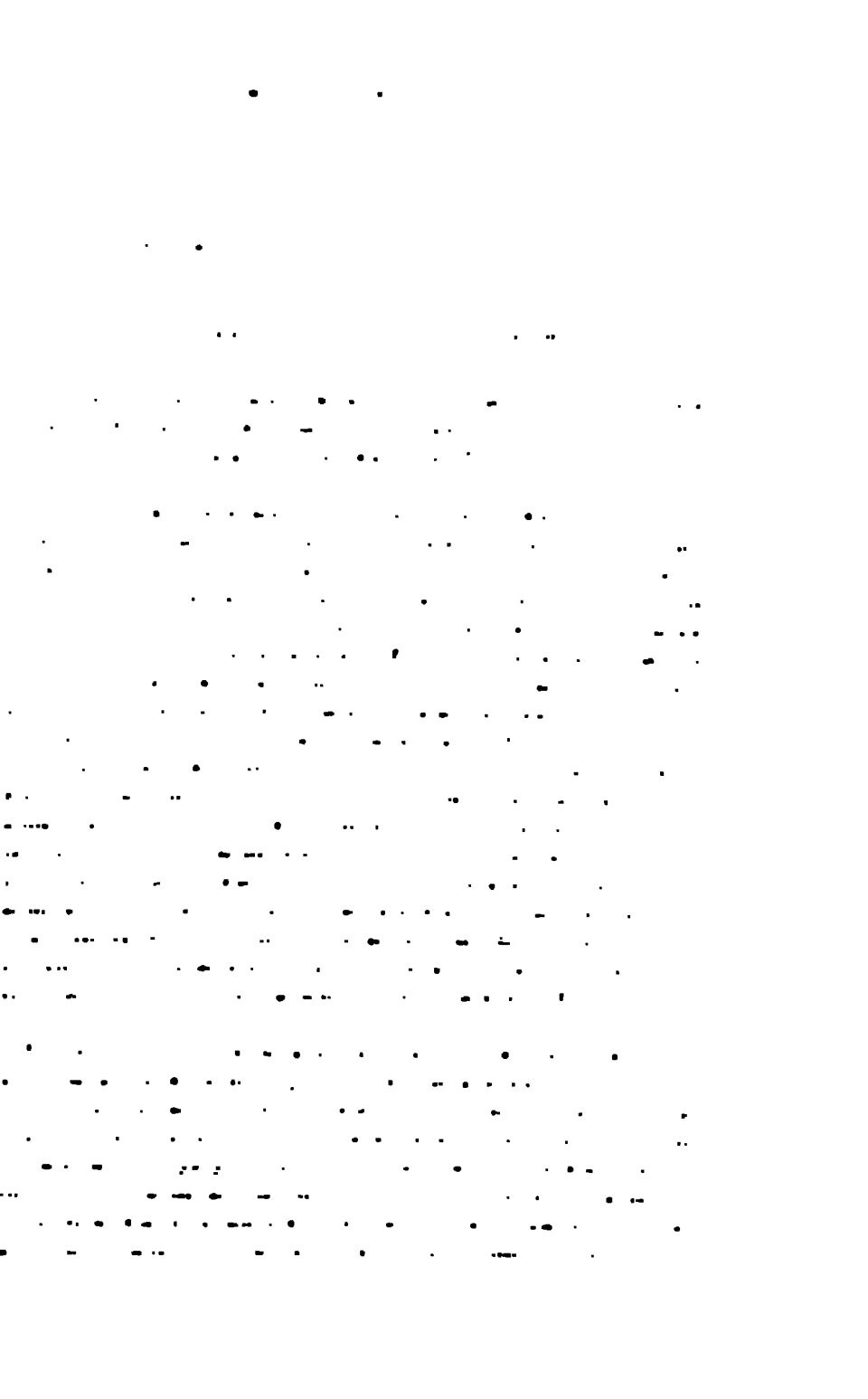
An apparatus for facilitating the removal of pigs from the moulds of Uehling's pig iron casting machines has been in constant use at the Lucy Furnaces of the Carnegie Steel Company. A pin carried by a piston rod strikes the pig as the mould brings it in front of the cylinder to which the supply of steam is controlled by the chain of the casting machine.†

The Utilisation of Blast-Furnace Gas.—The utilisation of blast-furnace gas in gas-engines is considered by E. Demenge,‡ as regards the quality and quantity of the gases produced by blast-furnaces, their present and future use in motors, the principal engines that lend themselves to such utilisation, and the blowing-engines driven by these motors. The whole of the paper is, in fact, a summary of what has been done in this direction, and it is supplemented by numerous illustrations of the engines and plant now at work, and an account of the Cavallier dust-catcher, previously referred to in this volume. The author adds a table showing the works owning gas-engines driven by blast-furnace gas, and giving the names of the builders of the engines, the situation of the works, the system, number, and horse-power of the engines, the number of their cylinders, and the uses to which they are applied. These uses include the generation of electricity, transmission of power, the driving of blowing-engines and air compressors, lighting, pumping, &c. The number and horse-power as distributed in various countries is as follows:—

* *Stahl und Eisen*, vol. xx. pp. 1033-1037, with 12 illustrations.

† *Iron and Coal Trades Review*, vol. lxi. p. 316.

‡ *Bulletin de la Société de l'Est de la France*, 1899-1900; *Colliery Guardian*, vol. lxxix. pp. 996-998.



tions, and the mechanical efficiency to nearly 82 per cent., the blast pressure being at the same time raised to 448 mm. The experiments are summed up in the statement that 28 per cent. of the heat was converted into work in the cylinder, 20 per cent. was lost in the waste gas and otherwise, while 52 per cent. was carried away in the cooling water.

The increasing use of large gas-engines for power purposes is discussed by M. Münzel.* A number of such engines are described, and the progress of the gas-engine considered generally, together with the establishment of central power stations. Some modern plants are dealt with in some detail.

The first tests of the 600 horse-power gas-engine constructed at the Seraing works to utilise the blast-furnace gases were made there on March 20 and 21. A description of this gas-engine is published.† The gas is taken from the main lead and is sent direct to the engine without any separation of the dust it may contain. The results were very satisfactory.

Details are published ‡ as to the very satisfactory results obtained in connection with the 600 horse-power engine driven by blast-furnace gas at Seraing. The engine was driven by gas taken direct from the boiler leads without further purification.

E. Meyer§ also deals at considerable length with the experiments made with the 600 horse-power engine driven by blast-furnace gas at the Seraing works, and working a blowing-engine.

The large engines at the Donnersmarckhütte and the Friedenshütte, which have been erected for the utilisation of blast-furnace gases, are described. According to Müller,|| there had been at work continuously for five months at the Donnersmarck works a 100 effective horse-power gas-engine, having a 19·7 inch cylinder, 33·5 inches stroke, and making 130 revolutions in the minute. It is used for driving a dynamo coupled direct to it. There has only been one stoppage for repairs in the whole five months, and that was merely to replace a spring forming part of the igniting arrangement, and consequently had nothing to do with the utilisation of the gas as the source of power. The blast-furnace gas used for this purpose is of about 1000 calories value, and contains per cent. by volume—

| Carbon Monoxide. | Hydrogen. | Carbon Dioxide. |
|------------------|-----------|-----------------|
| 31 | 3·4 | 7·8 |

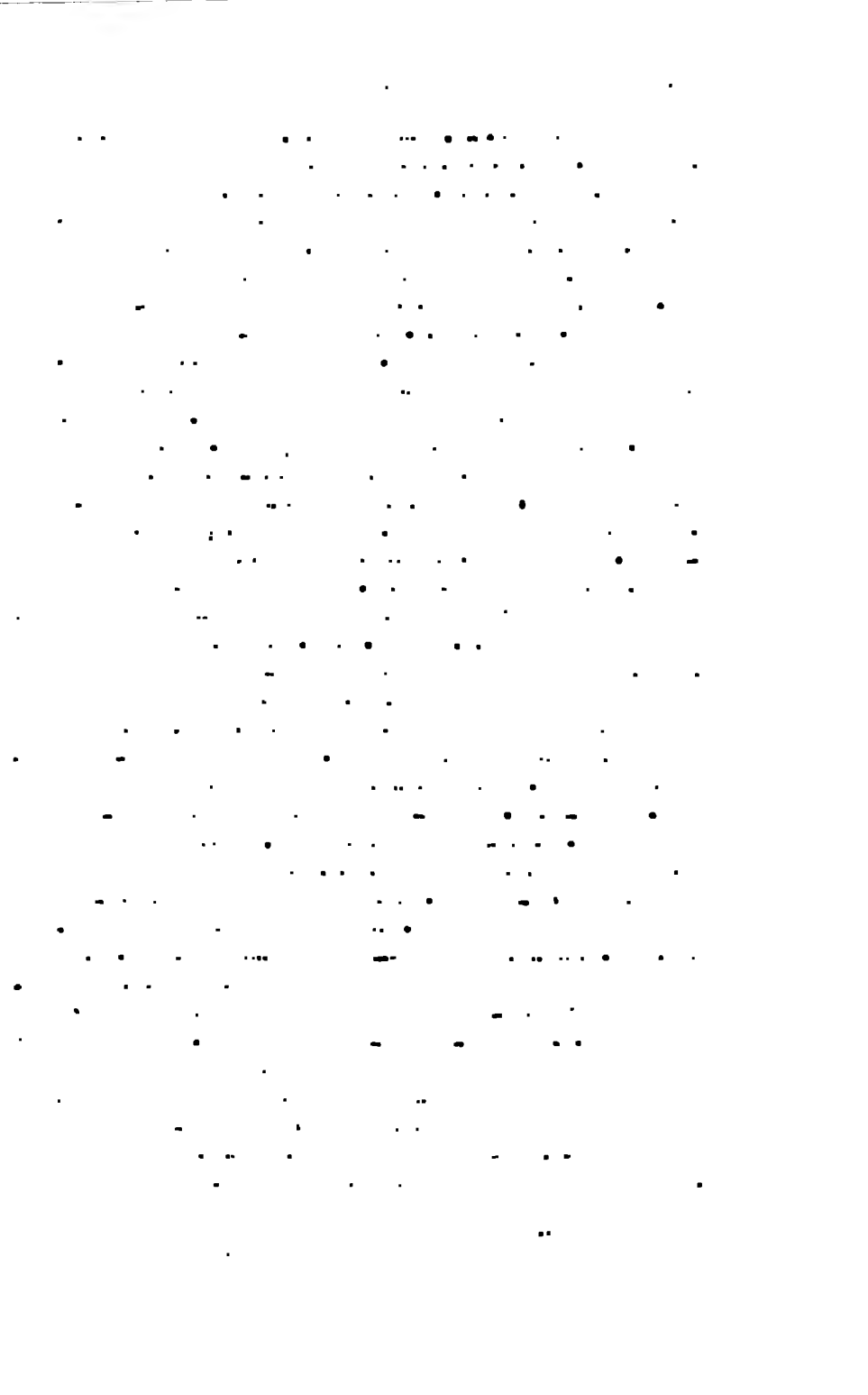
* *Stahl und Eisen*, vol. xx. pp. 315-320, 382-392, with 14 illustrations.

† *Ibid.*, p. 401.

‡ *Ibid.*, pp. 419-420, with two illustrations.

§ *Ibid.*, pp. 721-729, with three illustrations.

|| Paper read before the *Eisenhütte Oberschlesien*, January 21, 1900; *Stahl und Eisen*, vol. xx. pp. 413-416, with three illustrations.



pound of dust could be scraped out of the explosion chamber and from the piston bottom. When more than one blast-furnace is at work at the same time, the average composition of the escaping gases does not vary very greatly as a whole, but a regulator attached to the gas-engine permitting more or less gas to enter allows even for considerable variations in this direction. The moisture in the gas reduces its calorific power, but this has been found at the Friedenshütte to be quite high enough, given adequate compression, to yield the necessary power at the moment of explosion. The gas from the Friedenshütte blast-furnaces has to pass for a distance of about 550 yards before it reaches the gas-engine. It passes through a series of dry scrubbers. Some were at first filled with porous coke, but this soon clogged, and now these coke scrubbers are left empty. They finally pass through sawdust purifiers to a gasometer, whence they subsequently pass to the engines. The natural gas pressure, as it comes from the blast-furnace, is high enough to force the gas to the engines, where it still amounts to from 0·8 inch to 2·36 inches of water. The works possess two 200 horse-power Otto gas engines, and two of 300 horse-power each. The former are used for electric lighting, and the two larger engines for the electric transmission of power. These engines are described. The gas as it leaves the blast-furnace has a pressure of from 3·5 to 5·9 inches of water and a temperature of about 330° C. At the engines the pressure has fallen to that already mentioned, and the temperature to only 8° to 13° C. After passing the dry purifiers at the blast-furnace the gas contains about 5 grammes of dust per cubic metre (35·32 cubic feet). Just before the sawdust purifiers the quantity is only 0·6 to 1·6 gramme per cubic metre, and only a few thousandths of a gramme after passing through the sawdust. The moisture in the cubic metre of gas was found to be 13·5 grammes before the sawdust was passed through, and but 5·5 grammes afterwards. The gas as it enters the engines contains per cent. :—

Carbon Monoxide.
28 to 30

Hydrogen.
3 to 3·5

Carbon Dioxide.
6 to 7

The 200 horse-power engines, when working at only a 90 horse-power rate, use 233 cubic feet of blast-furnace gas, or 183·6 cubic feet of producer gas per horse-power and per hour. When, however, yielding 177 horse-power they only wanted 134 cubic feet of gas per horse-power hour, whence it will be seen that when doing their maximum work they require scarcely 124 cubic feet of blast-furnace gas per horse-power hour. The water required in the case of a 200 horse-power

greatest danger in the safe working of a gas-engine lies in the attainment of too high pressure and too high temperature. The use of "power gas" prepared on the Oechelhäuser system by the *Deutsche Kraftgas-Gesellschaft* is specially referred to. The use of power gas, as distinguished from blast-furnace gas, is generally dealt with, as also is the progress that has been made in the use of gas-engines, which, though long looked upon with favour theoretically, have only of late years begun generally to be adopted in practice on any large scale.

M. Münzel* compares the 600 horse-power Cockerill engine to be worked with blast-furnace gas with a 600 horse-power and a 1200 horse-power engine made by the Deutz Company. The latter have four cylinders. He shows that the latter possess advantages over the former.

A. D. Adams† points out that about half the energy of the gas is lost in the water used for cooling the cylinders of gas-engines, and in addition there is the waste heat in the exhaust. This heat might be utilised for hot water heating systems, or in other ways.

According to Osann,‡ there is produced in Germany and Luxemburg 920 tons of pig iron per hour. The gas resulting would be equivalent to the production of 377,200 horse-power per hour if gas-engines were utilised. The saving in coal would amount to about £16,500,000 per annum. The question of the utilisation of blast-furnace gases in gas-engines is dealt with generally by the author.

E. Meyer§ describes various gas-engines for using blast-furnace gas, including a 600 horse-power two-cycle Oechelhäuser engine. The stroke is 31·5 inches, and the diameter of the cylinders is 18·9 inches. The speed is 135 revolutions per minute, and the gas consumption is given as 124 cubic feet per horse-power hour.

The use of blast-furnace gas for motive power is described by O. E. Westin,|| who gives a historical summary of the development of the gas-engines used.

E. Theisen¶ describes his method for the purification of blast-furnace and other works gases. It consists in the use of a centrifugal gas-washer. One such apparatus has recently been erected at the Hörde works. It is cylindrical in form, about 5 feet in width by 15 feet in

* *Stahl und Eisen*, vol. xx. p. 1095.

† *Engineering Magazine*, vol. xix. pp. 523-528.

‡ *Zeitschrift des Vereines deutscher Ingenieure*, vol. xlv. pp. 886-887.

§ *Ibid.*, p. 1056, with plate.

|| *Jernkontorets Annaler*, 1900, pp. 369-461.

¶ *Stahl und Eisen*, vol. xx. pp. 1037-1041, with one illustration.

1. The first step is to identify the problem or question that needs to be addressed. This involves understanding the context and the specific requirements of the task.

2. Next, it is important to gather relevant information and data. This can be done through research, consultation with experts, or by analyzing existing data sets.

3. Once the information is gathered, the next step is to analyze it. This involves identifying patterns, trends, and potential solutions. It is important to consider all possible options and weigh their pros and cons.

4. After analysis, a decision must be made. This involves selecting the most appropriate solution based on the available information and the specific requirements of the task.

5. Finally, the chosen solution must be implemented. This involves putting the plan into action and monitoring the results to ensure that the problem is effectively solved.

1. The first step in the process is to identify the problem or issue that needs to be addressed. This involves gathering information and understanding the context of the problem.

THE

which particulars are given,* together with a plan and other illustrations. There are two furnaces 17 by 75 feet, with six hot-blast stoves 18 by 75 feet, and room for two more stoves. Five blowing-engines with air cylinders 54 by 84 inches are provided, and six 350 horsepower vertical tubular boilers. Each furnace has a casting-house 60 by 175 feet. The Kennedy filling arrangements are fitted to these furnaces, and these are also described.†

Some illustrations have appeared‡ of the blast-furnace and steel plant and collieries of the Ashland Coal and Iron Co. at Huntington, West Virginia. There are three blast-furnaces at work served by 12 stoves.

New Belgian Blast-Furnace.—At Couillet, in Belgium, a large new blast-furnace has been completed. It is the first blast-furnace of the American type erected on the Continent.§

Blast-Furnace at Malaga.—Details are given|| of the new blast-furnace just started at Malaga. The furnace is 80 feet in height, and its maximum diameter is 19 feet. There are three Cowper stoves in use and one in reserve. There are three boilers heated by the furnace waste gases. A 25-ton open-hearth furnace has also been built. The ore smelted in the blast-furnace is hæmatite from Casariche, with coke from Belmez. The present output is 80 tons a day.

II.—CHEMICAL COMPOSITION OF PIG IRON.

The Effect of Remelting Pig Iron.—T. D. West¶ gives some analyses to show the effect of remelting iron and scrap steel. The following table shows the effect of five remelts on charcoal pig iron:—

| | Charcoal
Pig Iron. | First
Remelt. | Second
Remelt. | Third
Remelt. | Fourth
Remelt. | Fifth
Remelt. |
|------------------------|-----------------------|------------------|-------------------|------------------|-------------------|------------------|
| Total carbon . . . | 3·94 | 4·10 | 4·30 | 4·47 | 4·68 | 4·76 |
| Graphitic carbon . . . | 3·06 | 2·90 | 2·42 | 2·90 | 2·67 | 3·16 |
| Combined carbon . . . | 0·88 | 1·20 | 1·90 | 1·57 | 2·01 | 1·60 |
| Silicon . . . | 0·82 | 0·75 | 0·63 | 0·66 | 0·57 | 0·59 |
| Sulphur . . . | 0·02 | 0·03 | 0·04 | 0·04 | 0·045 | 0·048 |
| Manganese . . . | 0·78 | 0·66 | 0·53 | 0·31 | ... | 0·25 |
| Phosphorus . . . | 0·232 | 0·248 | 0·274 | 0·237 | 0·254 | 0·271 |
| Specific gravity . . . | 7·01 | 7·30 | 7·35 | 7·40 | 7·47 | 7·46 |

* *Iron Age*, May 3, 1900, p. 17; *Iron and Coal Trades Review*, vol. lx. pp. 947-948.

† *Iron and Coal Trades Review*, vol. lx. p. 456.

‡ *Ibid.*, pp. 1033-1034.

§ *Mining Journal*, vol. lxx. p. 1061.

|| *Revista Minera*, vol. li, p. 481.

¶ *American Machinist*, vol. xxiii. pp. 428-429.

Section 1: Introduction

The first section of the document discusses the importance of maintaining accurate records. It highlights the need for consistency and the potential consequences of errors. The text is organized into several paragraphs, each focusing on a different aspect of record-keeping. The first paragraph introduces the topic, while the subsequent paragraphs provide detailed explanations and examples. The section concludes with a summary of the key points discussed.

The second section of the document focuses on the methods used to collect and analyze data. It describes various techniques and the steps involved in the process. This section is more technical and includes specific details about the procedures followed. It also mentions the tools and equipment used to facilitate the data collection process. The text is written in a clear and concise manner, ensuring that the information is easily understood by the reader.

Section 2: Data Collection and Analysis

The final section of the document provides a conclusion and a list of references. It summarizes the findings of the study and acknowledges the sources of information used. The text is written in a formal and professional style, suitable for an academic or technical report.

for some time in Belgium, in the North of France, and in Germany, where the supplies of puddlers' tap are now becoming exhausted. In view of the impending exhaustion and high price of best puddlers' tap in Great Britain, basic pig iron makers have recently turned their attention to these supplies of phosphoric chalk from the Somme district, and several lots have already been bought for delivery in the United Kingdom.

In Belgium blast-furnaces phosphoric chalk works well, and a comparison of furnace burdens, without and with phosphoric chalk, is given to show the advantage of using the latter in preference to puddlers' tap. These furnaces now use minette (Luxemburg) ore, mixed with Gellivare (Swedish) ore and phosphoric chalk, and no puddlers' tap or mill scale. On the furnace charge for pig iron containing about 1.94 per cent. of phosphorus, the use of chalk effected a saving of about sevenpence per ton. The tables appended show the analyses and weights of the materials used and produced.*

III.—BLAST-FURNACE SLAG.

Utilisation of Blast-Furnace Slag.—A plant for making slag cement and paving flags has been put into operation in Barrow-in-Furness. Two grinding machines of American make are fed from a large hopper capable of holding two trucks of slag, and each turns out five tons hourly, absorbing 50 horse-power. The ground material is bagged without being touched by hand. The slag dryer is a revolving cylinder 40 feet long.†

A. Birk ‡ describes the Königshof slag cement. The granulated blast-furnace slag from the Carl-Emil works at Königshof contains :—

| SiO ₂ . | CaO. | Al ₂ O ₃ . | MgO. | FeO. | MnO. |
|--------------------|-------|----------------------------------|------|------|------|
| 26.29 | 49.16 | 18.71 | 2.45 | 1.80 | 0.24 |

The three most important constituents vary, as a rule, as follows :—

| | Per Cent. |
|-------------------|-----------|
| Silica | 24 to 27 |
| Lime | 49 „ 54 |
| Alumina | 15 „ 19 |

This slag may be compared as regards composition with the slag from the Choindez ironworks, which has found general application in practice as in the form of slag cement. This slag contains :—

* Pamphlet communicated by Messrs. C. E. Muller & Co., of Middlesbrough.

† *Iron and Coal Trades Review*, vol. lxi. p. 773.

‡ *Technische Blätter*, 1899, Nos. 2 and 3; *Stahl und Eisen*, vol. xx, pp. 886-891.

• **What is the purpose of the study?** The purpose of the study is to determine the effect of a 12-week resistance training program on the strength and endurance of the lower extremities in healthy young adults.

Another analysis given by Tetmajer is also shown. The author next considers the properties of the Königshof slag-cement in detail. Its specific gravity lies as a rule between 2·80 and 2·90, and it is about 5 to 6 per cent. lighter than Portland cement. Being so light, it can be very readily brought into thorough admixture with sand and water. It sets somewhat slowly. A good cement must not increase its volume during the setting. An increase of volume is especially disadvantageous, and the Königshof cement gives excellent results in this direction, showing no increase of volume whatever. The author next gives in detail the results of a large series of tests of this cement, and shows that it is generally very satisfactory.

A. D. Elbers * discusses the use, on land, of slag from blast-furnaces, and shows that when it is of a basic nature it may be employed for liming purposes.

G. Kroupa † describes and illustrates some American methods for the removal of slag, but these, though of general interest, relate directly to lead and copper smelting. One such consists in the granulation of the slag and its subsequent removal by a current of water.

IV.—*FOUNDRY PRACTICE.*

Foundry Appliances.—R. Moldenke ‡ shows what an extensive field there is for the conveyor in foundries. For sand, coal, coke, and for the castings shaken out of the moulds it is especially suitable. It is also used to convey moulds to the casting point. For handling pig iron and leading it to the cupola or reverberatory furnace, the conveyor is not well adapted except in special instances.

J. A. Murphy § discusses some of the points which tend towards good work in foundry management, especial reference being made to good lighting, appliances, material and labour.

Illustrations have been published || to show the main foundry, cupolas, and charging floor, and a moulding pit at Cramp & Sons' foundry, Philadelphia. The floor area is 37,920 square feet, with 9000 feet of gallery space. Two 50-ton electric travelling cranes command

* *American Manufacturer*, vol. lxvii. pp. 276-277.

† *Oesterreichische Zeitschrift für Berg- und Hüttenwesen*, vol. xlviii. pp. 31-33, with numerous illustrations.

‡ *Iron Trade Review*, June 14, 1900, p. 26.

§ *Journal of the American Foundrymen's Association*, vol. ix., Part I., pp. 17-24.

|| *Iron Trade Review*, June 14, 1900, pp. 8-9.

1. Explain the importance of the following factors in the development of a country's economy:

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vertically, are used, and are rammed in a vertical position by hand or by machinery. Small pipes are usually moulded socket up, but pipes over 10 inches in diameter are moulded with the socket at the bottom. The moulds are dried from the inside by air passing through them as they are placed vertically in the oven. The cores are made by wrapping hayband on a steel core bar, and then coating it with clay which is subsequently blacked. Collapsible core bars and other substitutes for hayband have not answered. Cupola-melted iron is used for casting. The pipes are cooled, stripped, the core knocked out, and the fins, &c., cleaned off, after which the pipes are coated and then tested. Thin soil pipes are cast on the side in greensand with greensand cores.

C. A. Meissner * gives a specification for pipes used by the British Admiralty and others, and generally deals with various points arising in their manufacture and use.

Cast Iron for Hydraulic Castings.—R. P. Cunningham † discusses the mixing and melting of iron for hydraulic castings, and advocates mixtures containing 1·20 to 1·50 silicon, 0·60 to 0·80 phosphorus, 0·40 to 0·60 manganese, and sulphur as low as possible, in order to obtain close-grained castings, which will prevent water under pressure from coming through. Care in the use of scrap and the use of plenty of fuel is requisite.

Chilled Rolls.—The manufacture and care of chilled rolls is dealt with in a recent article. ‡ Uniformity of composition and careful selection of material is very necessary, and great care is requisite to get a chill of uniform depth. The metal is generally melted in air furnaces, and cast from below in vertical chill moulds, with sand at the necks and wobblers. Until recently, nearly all the tinplate rolls in the United States were 24 inches in diameter, and generally 36 inches or 38 inches long. The rolls used in the first tinplate works in the United States were smaller than this, and those used in Wales were still smaller, the Welsh rolls being from 16 inches to 18 inches in diameter, and correspondingly short. Now a great many tinplate rolls in the United States are 20 inches in diameter, and from 40 inches to 44 inches in length. The life of the roll is then dealt with,

* *Journal of the Mining Society of Nova Scotia*, vol. v. pp. 47-54.

† *Journal of the American Foundrymen's Association*, vol. ix. pp. 36-40.

‡ *Iron and Coal Trades Review*, vol. lxi. pp. 416-418.

| Combined
Carbon. | Graphitic
Carbon. | Si. | Mn. | S. | P. |
|---------------------|----------------------|------|-------|-------|-------|
| 2.60 | 0.72 | 0.71 | 0.110 | 0.045 | 0.039 |
| 0.82 | 2.75 | 0.73 | 0.108 | 0.04 | 0.039 |

The presence of silicon is necessary for the change of the carbon to be effected. When it is absent there is practically no alteration, however long the heating may be continued. Manganese also has an effect, which is, however, often masked by that of the silicon which it protects from oxidation rather than acting directly on the carbon like silicon. Iron low in silicon and manganese is practically worthless after annealing, as it is deficient in tenacity although it is softened. The carbon is changed to what Ledebur terms graphitic temper carbon. When it is not fully developed by over-annealing, it passes easily into the hardening condition.

H. O. Evans * discusses the shrinkage of malleable iron castings. The contraction in the casting is taken as $\frac{1}{4}$ -inch per foot, but during annealing expansion takes place to a variable amount, depending on the dimensions and on the time and temperature of annealing. Some general rules are given, but practical experience is the only true guide for the determination of the amount.

A note has appeared † giving the distribution and names of the firms making malleable castings in the United States, and also some general remarks on the manufacture.

* Paper read before the Foundrymen's Association, April 4, 1900; *Iron Trade Review*, April 5, 1900, p. 7.

† *Engineering and Mining Journal*, vol. lxx. pp. 275-276.

Page 10 of 10

purposes, and of lime and silica for fluxing. The ore and these additions are made into a paste by the addition of some 5 to 10 per cent. of tar, and subsequently pressed into briquettes. It is with these briquettes that the furnace is charged. In one experiment quoted there was produced in 35 minutes $17\frac{1}{2}$ lbs. of iron, at an expenditure of a little more than one hour horse-power per pound of iron made.

John B. C. Kershaw * also describes the Stassano process for the production of iron and steel, which is being tried in Italy, and discusses the economy of the electric current when used for heating.

History of Iron.—The question when iron was first used was discussed by the celebrated Swedish archæologist Montelius at the thirty-first general meeting of the German Anthropological Society at Halle. Formerly it was generally believed that iron was not employed in the North, Scandinavia and North Germany until a very late date, about 900 A.D., and even within the last thirty years it has been thought that iron could not have been used in Scandinavia before 300 A.D. In Southern countries, however, iron was known at an extraordinary date. This was notably the case in Egypt, for it cannot be imagined that huge buildings, like the pyramids, could have been built without tools. Montelius is of opinion that in Egypt iron was not used before the middle of the twentieth century B.C. This view is supported to a certain extent by the new discoveries made by Flinders Petrie. One of the graves investigated by him dates back to 3000 B.C. In neither case was there a trace of iron discovered. Moreover, in Greece the earliest occurrence of iron was in the fourteenth century B.C. In view of the close relations with Egypt, so late a use of iron is inconceivable, if iron had been known in Egypt for thousands of years. Montelius concludes that iron appeared in Central Italy with the Etruscans about the year 1100 B.C. In Northern Europe it appeared soon afterwards. For example, it is found in the pile dwellings in Switzerland contemporaneously with bronze, and consequently for Switzerland and South Germany the tenth and ninth century B.C. may be taken as the starting-point of iron. Farther north, in a grave in Bornholm, iron dating from 1200 A.D. has been found.

* *Electrical Review*, June 15, 1900.

State of Texas vs. George W. Bush

THE STATE OF TEXAS, by and through the undersigned Attorney General, do hereby certify that the within and foregoing is a true and correct copy of the original as the same appears in the files and records of the State of Texas.

WITNESSED my hand and the seal of the State of Texas at Austin, this 1st day of January, 1901.

ATTEST:

Attorney General

front of the finishing train used 18 horse-power running idle, and the power increased to 122 horse-power at the end of the operation, which took 327 seconds. Similarly on the live rolls in front of the roughing rolls the power ranged from 15 to 92 horse-power.*

O. Lasche† describes the copper rolling-mill at the Oberspree cable works near Berlin, where the roughing and finishing trains are driven by electromotors. The former has four stands, and is driven at 108 revolutions per minute by a three-phase motor through rope gearing. This motor gives 200 horse-power at 380 revolutions, taking current at 500 volts. The finishing rolls in seven stands are driven direct by a 400 horse-power motor, at 420 revolutions, a flywheel being provided. In eleven hours 27 tons of wire are rolled from bars 12·4 square inches in sectional area, and weighing 130 lbs. each; the wire produced being 0·275 inch in diameter. The mill has been at work for eighteen months. The author then discusses the size of three-phase motors required for rolling-mill work.

Modern Rolling-Mills.—E. Weber‡ discusses the arrangements of modern rolling-mill plant, and makes suggestions as to the ways in which these could be improved. Some comments have appeared§ on the design of roll-bearings and their lubrication. The researches of R. Job|| on bearing metals are especially mentioned.

Ehrhardt¶ discusses some points connected with modern rolling-mill practice, considered especially with modern efforts to roll an ingot at one heat to the greatest possible length. Some modern forms of mills are dealt with.

P. Eyermann** describes some modern American rolling-mill plants. These include one at Duquesne, Pennsylvania, and a modern plate-mill at Homestead, Pennsylvania. An older one at the latter place for large sections is also described.

P. Eyermann†† describes a continuous rolling-mill erected at Youngstown, Ohio. According to the shapes rolled, it can make up to 600 tons output daily, starting with small billets, and rolling them to hoop-iron used in binding cotton bales.

* *Iron and Coal Trades Review*, vol. lxi. p. 314.

† *Technisches Centralblatt; Electrician*, vol. xlv. pp. 698-702.

‡ *Stahl und Eisen*, vol. xx. pp. 421-424, with three illustrations.

§ *Iron and Coal Trades Review*, vol. lxi. pp. 774-775.

|| *Journal of the Franklin Institute*, vol. cxlix. pp. 439-450.

¶ *Stahl und Eisen*, vol. xx. pp. 871-874, with five illustrations.

** *Ibid.*, pp. 730-737, with five illustrations.

†† *Ibid.*, pp. 982-984, with an illustration.

contents in an unknown state, sometimes fluid, semi-fluid, pasty, or granular, passed to the blooming-mill and reduced from 16 or 18 inches, an average modern-sized ingot, having 288 square inches of area, to a bloom 8 inches square, having 64 square inches of area, which is a reduction of 224 square inches in 11 passes, or 20·4 square inches of reduction to each pass, instead of 11·3 as formerly, which is nearly 100 per cent. faster; in addition to which the train is now-a-days driven at a higher rate of speed than formerly. The 8 by 8 inch bloom thus produced is not allowed to cool, but is charged into a heating furnace and held hot, or in some cases proceeds without further heating direct to the rail-mill, where it is reduced to a 70-lb. rail in nine passes instead of 13, by rolls running 900 feet per minute, instead of 400 as formerly, which is over 60 per cent. more rapid reduction, pass for pass, leaving out of consideration the speed at which it is done, which has an important bearing on the final result. Owing to all this haste, the rails finish at a high temperature, and the heads practically anneal and soften on the cooling beds. As the size increases, the difficulty of controlling the finishing temperature also grows, and it has been suggested that the rails should be passed through an additional furnace to equalise the temperature in the head and foot before the finishing passes, and thus to ensure a proper finishing temperature.

Nickel steel railway rails have been rolled for the Pennsylvania Railroad Company, and laid on the west track of the famous horse-shoe curve near Altoona. A letter from W. H. Brown,* the chief engineer of the Company, gives the following details of this installation. The order for 300 tons of 3 per cent. steel rails was placed with the Carnegie Steel Company on June 26, 1899. The steel was made by the Bessemer process, and the rail was rolled to the 100 lbs. Am. Soc. C. E. section. In rolling, the nickel content caused "red shortness" to such an extent that the rolling resulted in only 220 tons of No. 1 and 57 tons of No. 2 rails, and 19 tons of the latter had to be thrown away because of piping. The average analysis was as follows:—Carbon, 0·504 per cent.; phosphorus, 0·094 per cent.; manganese, 1 per cent.; and nickel, 3·22 per cent. Under the straightening presses the rails showed great rigidity, twice the force ordinarily used being required to accomplish the cold straightening, and often the rail would spring back to its former position after being struck. In drilling, the hardness was even more marked, in some cases five

* *Railroad Gazette*, vol. xxxii. p. 195; *Engineering News*, vol. xliii. p. 217.

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Figure 1. The effect of the concentration of the *Agrobacterium* suspension on the transformation efficiency of *Agrobacterium* strains. The number of transformed cells was determined by the number of colonies obtained on the selective medium. The results are the mean of three independent experiments. Error bars represent the standard deviation.

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PRODUCTION OF STEEL.

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| III. The Bessemer Process | 528 |

I.—THE CARBURISATION OF MALLEABLE IRON.

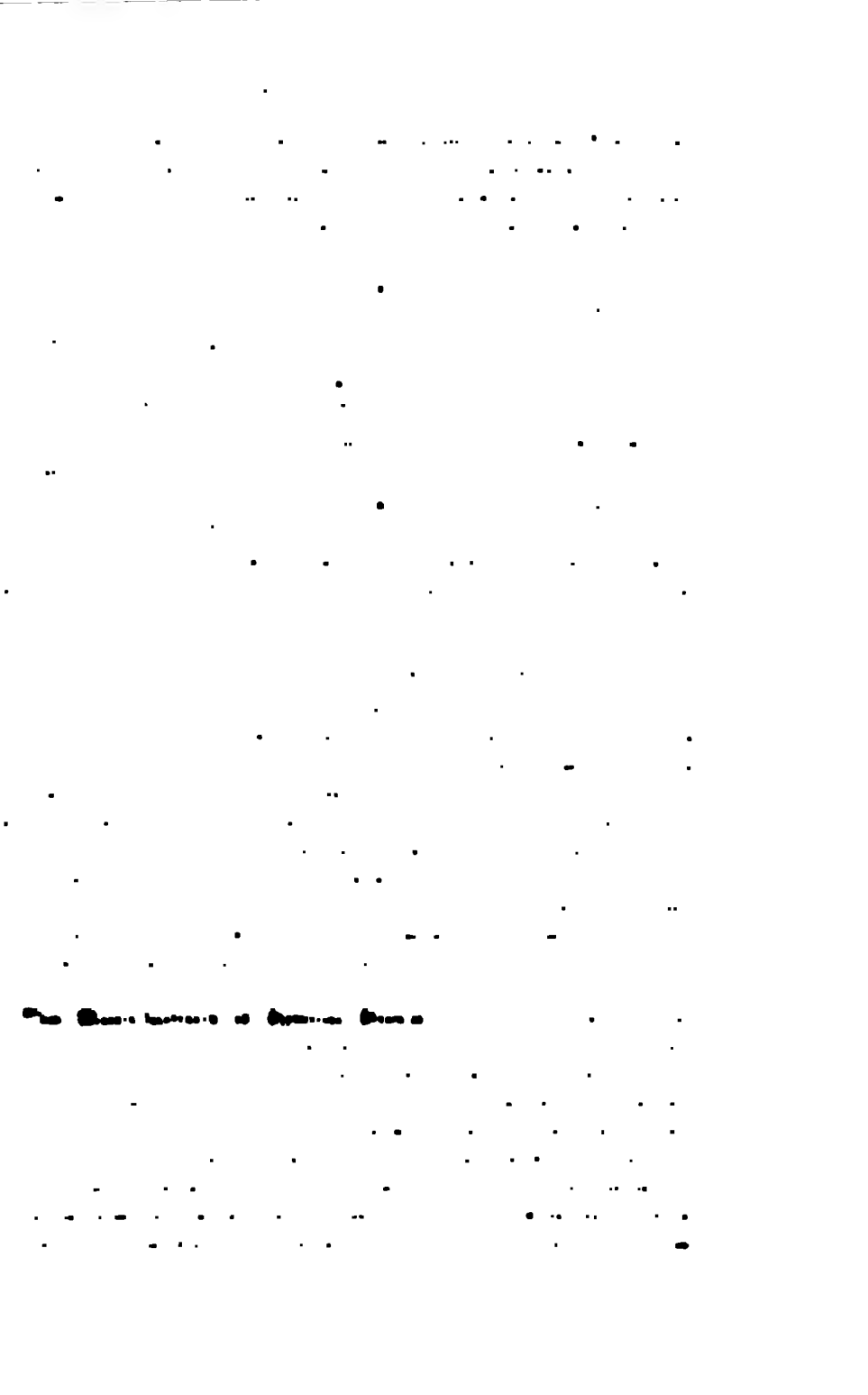
Direct Production of Steel.—The Rudolphi-Landin method for producing steel direct from the ore is described in a recently published pamphlet.* The ore, in a more or less fine state of division, is mixed with carbonaceous and binding material, and also with any fluxing material that may be required. The mixture is compressed into briquettes and passed through a long furnace, in which they are first dried, and then the oxide of iron is reduced to a sponge of metallic iron. The reduced briquettes are then dropped direct into a bath of molten metal, which, is kept covered with slag. Preferably a 20-ton tilting-furnace is used, and a portion of the bath is withdrawn at intervals of about four hours. This metal is transferred by a ladle to a steel furnace of the open-hearth type, and there finished. A sketch plan of the suggested plant is given, while the thermal requirements and possible advantages of the process are discussed by H. Tholander and P. Hördén.†

The Sands Employed in Casting Steel.—A. Coroux ‡ describes the sands used in casting steel. Among the natural materials used for this purpose the author enumerates, in the first instance, powdered quartz, obtained by heating quartz to a high temperature and then plunging it into cold water. After such treatment it can be readily

* A copy is in the Library of the Iron and Steel Institute.

† *Teknisk Tidskrift*, vol. xxx. pp. 60-64.

‡ *Bulletin Technologique*, 1900, pp. 816-820.



regards special steels, but our knowledge at present with regard to this matter is defective. As stated before, in the special steels carbon to a certain degree is always also present. With manganese steel it is found that the critical points of the alloy vary with the varying proportions of these two constituents, and the presence of manganese retards the magnetic transformation and lowers the point of recalcence. In nickel steel the addition of 5 per cent. of this metal to carbon steel lowers the point of recalcence 300°. The phenomenon of hysteresis in the case of nickel steels assumes an abnormal and excessive character. With 4 per cent. there is a difference of 100°. These steels, therefore, are termed "irreversible" alloys. In chrome steel carbon is always present to a relatively considerable extent, and the critical points are found to correspond to those of carbon steel. The same remark holds good with regard to tungsten steel. When the latter is suddenly cooled at a temperature above the critical point, it presents the properties of hardened or tempered steel. In silicon steel the constant presence of manganese prevents us judging the influence of silicon on the critical point. The manufacture of the special steels in large quantities in the open-hearth furnace is attended with many difficulties—notably in the case of chromium, which oxidises at a high temperature; hence metal-work with a higher percentage than 3 is not melted. Such is the composition of the chrome nickel steel used for ordnance or armour plates. Silicon steel is employed by many works for making springs. Bessemer metal is welded easily, and has a temperature 200° or 300° higher than open-hearth steel, so that, with the aid of a converter of a capacity of one or two tons, founders have succeeded in producing castings weighing from four to five tons—by accumulating the charges in a receiver. With a converter of twelve tons, castings up to thirty tons could, if required, be easily made. The manufacturers of machinery, bicycles, motor-cars, &c., demand from the steel-foundries thousands of small pieces which formerly were forged or made of cast iron. The industry of steel bells has, indeed, not developed, since they conflict with the tradition that bells should be of bronze, nevertheless the former are cheaper and more solid, and, above a certain weight, comparable with the latter in tone. The Alexander III. bridge at the Paris Exhibition is constructed of cast steel. In engineering, the application of steel plates for hydraulic cylinders, boilers, &c., is extensive; steel shafts are now cast as strong as those of forged steel; machine frames and steam-cylinders twice as light, twice as strong, as cast iron; geared

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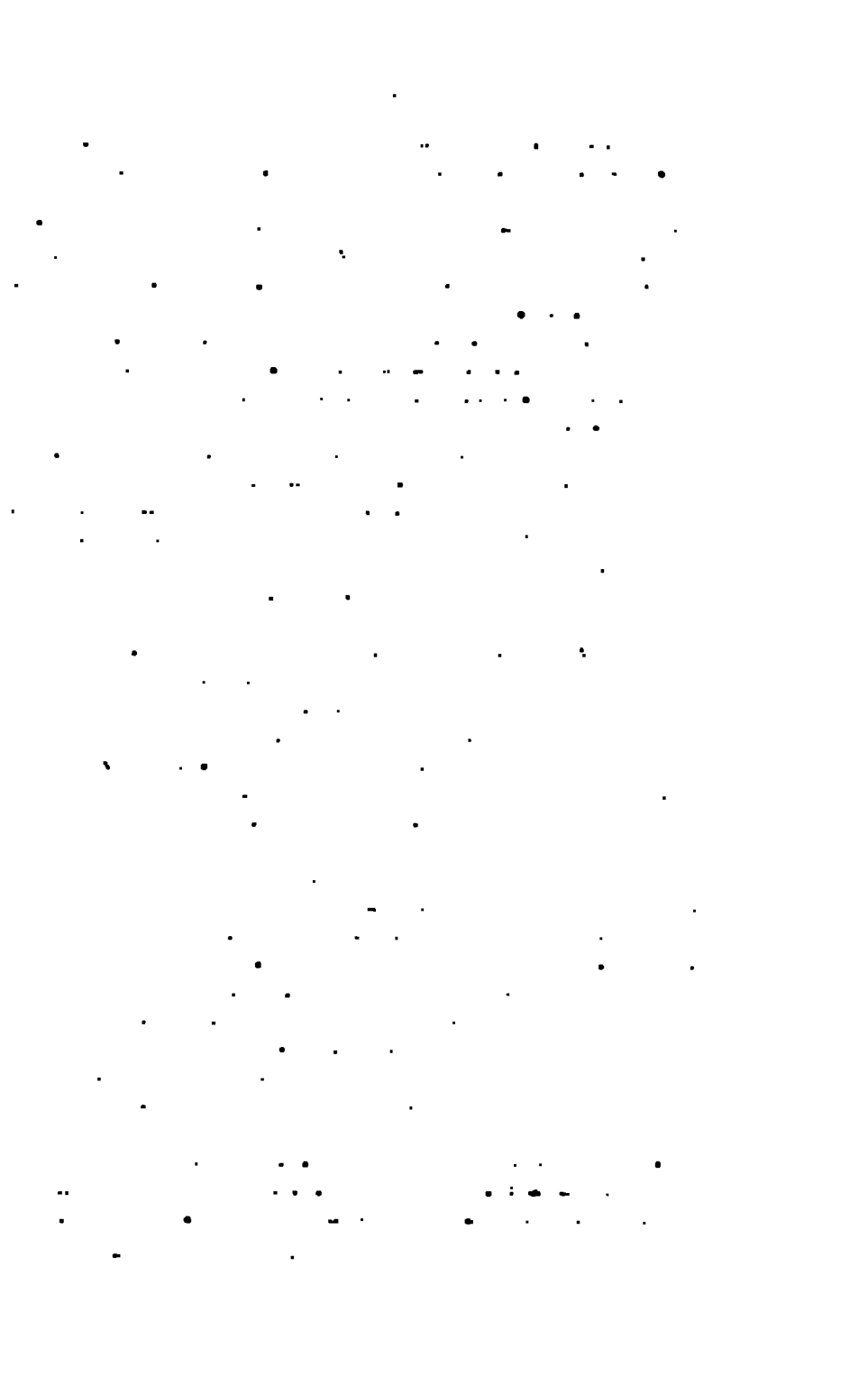
States. To such a mixer additions of scrap, spiegeleisen, and other varieties of pig iron can be made in the solid state without any deleterious effect. An automatic registering pyrometer gives the exact temperature of the escaping products of combustion, air and gas being thus completely under control. While the ordinary charge for a converter a few years ago was 7 to 12 tons, now-a-days charges of from 12 to 20 tons are preferred. Large charges mean greater uniformity of product. The converters themselves, and their linings and bottoms, have of late years been very greatly improved. The author considers the addition of ferro-manganese in the ladle not to be a satisfactory method of making such addition. It is not necessary, either, to allow metal to stand in the ladle before casting. A thorough admixture has been ensured by the pouring of the metal from the converter into the ladle. The author has proved this by a number of comparative assays.

A series of curves are shown relating to a 100-ton mixer used for pig iron. The phosphorus showed on standing a diminution of 0.02 per cent. with metal containing about 1.8 to 2 per cent. of phosphorus; a loss of 0.03 per cent. of silicon with metal containing about 0.15 to 0.5 per cent. of silicon; while the sulphur diminished by about 0.04 per cent., the original metal containing mostly less than 0.1 per cent.

In dealing with the open-hearth process the author considers the introduction of movable furnaces to have been a marked improvement. He also deals with the duration of the charge in the furnace, and recommends rapid working. Rolling-mills and soaking-pits are referred to, and methods of casting steel considered. The liquation within the ingot and the heads in casting are briefly mentioned. The liquation takes place more readily and completely in larger ingots. A slight addition of silicon or aluminium tends to prevent the liquation. Great stress is laid by the author on the value of etching tests. The value of properly theoretically trained individuals in controlling the work of the practical man is also shown. The author next considers the influence exerted by various elements, such as silicon, oxygen, and phosphorus. Oxygen he considers to be a far more dangerous enemy to steel than is phosphorus. A lengthy and important discussion ensued on the reading of this paper.

The Tilting Open-Hearth Furnace.—H. M. Howe,* on the authority of S. T. Wellman, states that a fore-hearth or casting-shoe

* *The Mineral Industry*, vol. viii. pp. 378-379.



that in the former. It is this that has probably caused the Bessemer process to hold its own so well. The author illustrates a form of combined converter and tipping open-hearth. This consists of a tipping open-hearth provided with tuyeres at the side. When it is desired to subject the pig iron to a preliminary treatment for the open-hearth method, the furnace is tipped so as to allow the blast entering through the tuyeres from the blast-furnace main to come into action. The furnace can be subsequently turned up again, the blast stopped, and the ordinary open-hearth method be proceeded with.

The Continuous Open-Hearth Process.—H. M. Howe* describes the Talbot process, and discusses its various features in some detail under the following headings:—The furnace, procedure, advantages, waste in melting down, maintenance of sides, bottoms, and roof, wider range for composition of pig iron, rapidity of operation and re-phosphorisation. The Bertrand-Thiel process is also compared.

Verney† also describes the Talbot open-hearth steel process.

In a letter recently published‡ a comparison is made between the two processes, the Bertrand and the Talbot. Both deal effectively with molten pig iron, and rely for successful operation on reduction of iron ore by means of the metalloids in the pig iron. For the capital involved, the Bertrand process seems to produce a good deal of steel; from the figures available nearly three times as much. The labour cost therefore is less. The Bertrand process produces a highly phosphoric slag, which is valuable, while the Talbot process produces a lean slag, which is not of great value. The Bertrand process shows a gain of 2 to 3 per cent. in yield on materials charged, while the Talbot process shows a gain of 5 to 6 per cent. The Bertrand process admits of the use of the fore-hearth, recently so successfully introduced in America, which obviates the necessity of the costly and treacherous ladles and stoppers. The Talbot process necessitates the use of a ladle. On the other hand, the Bertrand process delivers its full charge at once to the mills, while by manipulation the Talbot process can give a more continuous supply of ingots. Further discussion has ensued.

Joseph Hartshorne§ gives some further notes on the Bertrand-Thiel process.

* *The Mineral Industry*, vol. viii. pp. 368-378.

† *Comptes Rendus Mensuels de la Société de l'Industrie Minérale*, 1900, pp. 62-65.

‡ *Iron and Coal Trades Review*, vol. lxi. pp. 178, 211.

§ *Transactions of the American Institute of Mining Engineers*, February 1900.

Section 1: Introduction

The purpose of this document is to provide a comprehensive overview of the project's objectives, scope, and timeline. The project aims to develop a new software application that will streamline the workflow of the department and improve efficiency. The scope of the project includes the design, development, testing, and deployment of the application. The timeline for the project is estimated to be 12 weeks, starting from the beginning of the month and ending by the end of the month. The project will be managed by the project manager, who will be responsible for coordinating the team and ensuring that the project is completed on time and within budget. The project will be divided into several phases, including the initial planning phase, the design phase, the development phase, the testing phase, and the deployment phase. Each phase will have specific tasks and deliverables that will be tracked and reported on regularly. The project will also involve regular communication and collaboration between the team members and the project manager. The project manager will be responsible for providing updates on the project's progress and any issues that arise. The project will be considered successful if it meets the project's objectives and is completed on time and within budget.

Section 2: Project Objectives

The project has several key objectives that will guide the team's work. The first objective is to identify the current workflow and identify areas for improvement. The second objective is to design a new software application that addresses the identified areas for improvement. The third objective is to develop the application using the design as a guide. The fourth objective is to test the application to ensure that it meets the requirements and is user-friendly. The fifth objective is to deploy the application and monitor its performance. The project will be considered successful if it meets all of these objectives. The project manager will be responsible for ensuring that the team is working towards these objectives and that the project is completed on time and within budget. The project manager will also be responsible for providing updates on the project's progress and any issues that arise. The project will be considered successful if it meets the project's objectives and is completed on time and within budget.

Australian Steel Plant.—It is stated * that the first open-hearth steel furnace in New South Wales was started on April 26, 1900, at the Eskbank Works, Lithgow. It is a 5-ton furnace.

New American Open-Hearth Plant.—Plans and illustrations have appeared † of a new open-hearth plant at Newburg, Ohio. A similar plant has also been erected at Worcester, Massachusetts. One clear span 54 feet wide and 391 feet long covers four Wellman tilting furnaces and leaves room for a fifth, while a lean-to 35 feet wide covers the charging floor. Each furnace has a capacity of 50 tons. Two lines of crane girders carry two ladle cranes each of 75 tons capacity, and the furnaces can be poured into the ladle or through a fore-hearth into the moulds direct. The cranes also command the furnaces, so that the removable ports can be readily charged. The charging platform carries four lines of rails for the charging-box trolleys and the Wellman charging machine. In the rear is a line of fourteen gas producers $12\frac{1}{2}$ feet in diameter.

F. Lürmann, jun., ‡ describes the Apollo Open-Hearth Steelworks and rolling-mills situated at Poulton, near Pittsburgh. This work possesses three 30-ton acid open-hearths, the steel from which is rolled into sheets. It contains :—

| Carbon. | Manganese. | Silicon. | Phosphorus. |
|-------------|------------|-----------|-------------|
| 0.115-0.130 | 0.30-0.36 | 0.24-0.25 | 0.064-0.112 |

At the time of the author's visit in November 1898, these works, he says, were generally considered to be the best arranged of their kind in the United States. He describes them in detail with the aid of numerous illustrations.

An illustrated detailed description of the open-hearth steel plant of the Alabama Steel and Shipbuilding Company at Ensley, Alabama, has been published.§

III.—THE BESSEMER PROCESS.

The Working of Bessemer Converters.—In the annual report of the Chief Inspector of Factories and Workshops, a report by H. P.

* *Sydney Morning Herald*, April 26, 1900, through the *Iron and Coal Trades Review*, vol. ix. p. 1137.

† *Iron Trade Review*, July 5, 1900, pp. 12-14.

‡ *Zeitschrift des Vereines deutscher Ingenieure*, vol. xlv. pp. 1324-1327. with 12 illustrations.

§ *Iron Trade Review*, August 23, 1900, pp. 11-14.

From the report of the Commission

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eight years ago by Chang-chi-Tung, under the auspices of the Chinese Government. It lies on the banks of the Yangtse, and within easy reach of the Taye mines, from which the ore is brought by a fifteen-mile railway to a point on the river only forty-five miles from Han-yang. The ore deposits at Taye are extensive, and the quality is excellent, the ore being mostly magnetic, and containing on an average 63 per cent. of iron and only 0.05 to 0.08 of phosphorus. The Japanese are now resorting to these mines for the supply of ore for the steelworks at Wakamatsu, near Moji, Japan. The chief drawback at Han-yang is the scarcity of coke, though an enormous quantity of good coal can be obtained in or near the Yangtse Valley. The plant comprises a blast-furnace equipment, puddling furnaces, and rolling-mills, two Bessemer steel converters, an open-hearth plant, rail-mills, machine shops, foundry, &c., fairly complete and modern in most respects at the time of installation. The two blast-furnace stacks are 64 feet high. With good coke these furnaces will, it is claimed, produce from 75 to 80 tons each per day, but as the coke ordinarily used is poor, the average production is not over 60 tons. There are twenty single puddling furnaces of the usual size, and built in groups of four, the waste gases being used to heat a vertical boiler. Five-hundredweight charges are treated in each, and the blooms are worked under two 3-ton steam-hammers, and passed through a 20-inch train of roughing rolls. Sheet-mills are supposed to be included in the plant, but do not appear to be in operation. The two Bessemer converters are of 5 tons each, and there is one 12-ton open-hearth furnace of ordinary construction supplied by four Wilson gas-producers. The rail-mills are of no special interest. The foundry has a 20-ton travelling crane and three cupolas.

The Manufacture of Basic Slag.—A report by H. P. Smith upon the conditions attending the crushing of basic slag appears in the report of H.M. Chief Inspector of Factories and Workshops, from which it appears that the crushing is done by one of the following systems:—(1) In Krupp ball, otherwise known as "Herm Lohnert," mills. (2) By the edge-runner system. (3) By ball-mills, with cylindrical pebble mills used as auxiliaries. (4) By a combination of edge-runners, rollers, and separators. The effect of the recommendations made by the Dangerous Trades Committee are dealt with at some length.

Cupola Practice in Bessemer Steelworks.—According to S. M. Rogers,* there is no essential difference in the construction of the

* *Journal of the American Foundrymen's Association*, vol. ix. Part i. pp. 40-46.

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FURTHER TREATMENT OF IRON AND STEEL.

The Manufacture of Steel Castings.—In a paper read at the Paris International Congress on Mining and Metallurgy, A. Tissot* deals with the present condition of the manufacture of steel castings. It is fifty years since the first steel castings were made, but until quite recently the production was very limited, owing to the difficulty of obtaining the liquid metal in sufficient quantities for making very large castings. Attempts were made at the time of their first appearance to utilise the Bessemer converter and the open-hearth furnace, but not with good results. About 1885 Robert invented his converter with side blast, which, applied to the casting of steel, enabled the works to produce complicated castings of excellent quality, and, in fact, created a new industry, for the sphere of their utility has been extending ever since. Many difficulties have, however, had to be surmounted by the steel-founders, and it is only in virtue of their perseverance and ingenuity that the new craft has become a success. The melting-point of steel is very high, ranging from 1450° to 1500° C., and in working the metal still higher temperatures are employed. This high melting-point, and the contraction which steel undergoes when it cools, were the source of much vexation to the steel-founder. This shrinkage amounts to from 1·5 to 1·8, or even 2·0 per cent., according to the heat and composition. If the mould offers too great a resistance to this contraction, there is a risk of the casting cracking or becoming crooked. The third source of anxiety was the appearance of flaws, because it is necessary that a steel casting should be perfectly sound. The united efforts of the manufacturers of steel and of the founders have, however, overcome every difficulty. After many experiments, it was discovered how to prepare a suitable refractory sand, capable of withstanding the intense heat of the molten

* *Iron and Coal Trades Review*, vol. lx. pp. 1228-1229.

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for castings, and only rarely are ingots run from them. The converter, with the lateral blast of Robert, or its imitations, has now come into general use, and seems to satisfy all the remaining requirements of the steel-founder. Owing to the peculiar arrangement of the tuyeres, the output can be varied from 0·8 to 2 tons, or from 3 to 4 tons in the two types of the apparatus in use. The metal is milder than that produced by the open-hearth furnace. It possesses great power of resisting shocks and a degree of elasticity which attains 69·8 tons per square inch; it is, therefore, naturally well adapted for war material and marine purposes. Nickel steel with varying proportions of the first-named metal is now also largely manufactured for armour-plates, artillery, &c. The first special steels which were introduced, such as chrome and manganese steel, did not produce any greater difficulties in working than ordinary steel. The conditions in forging, tempering, and annealing were much the same as in carbon steel. Later varieties, notably those with a large admixture of nickel, owing to their extraordinary properties, presented difficulties of a formidable nature. Certain steels at the temperature at which carbon steel can be forged become hard. In others, the process of annealing seems to have an action the very reverse of that it has on ordinary steel, and so forth. It required innumerable experiments and much scientific research to arrive at suitable methods of working the new alloys. According to the theory of Curie, steel should be tempered when it is in a feeble magnetic condition at a high temperature. The determination of the point of magnetic transformation would be sufficient, therefore, in any case, to determine the temperature suitable for tempering. Before the new alloys—notably nickel steel—could be introduced into practical industry, many difficulties had to be overcome, owing to their extreme hardness, which the drills, the cutters of the planing machine, &c., could not attack. However, by annealing the metal and the use of specially made tools, and by working at a reduced speed, the trouble has been overcome. The metal adopted at the works of Imphy for machine tools is chrome tungsten steel tempered.

An account is published of the life of J. Mayer,* who is stated to have been the originator of steel castings. Though steel had long been known, yet only those of its properties were fully understood which it possessed in common with wrought iron, until in 1851 Mayer showed that this metal could be used in a similar way to cast iron, all attempts

* *Zeitschrift des Vereines deutscher Ingenieure*, vol. xxxiv. pp. 1368-1371.

1. The first part of the paper is devoted to a discussion of the

2. The second part of the paper is devoted to a discussion of the

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tool steel which accomplished some remarkable results. When the members of the Iron and Steel Institute were in the building it was employed to turn a mild steel shaft, and the cutting speed was 150 feet per minute. The tool worked dry, and the cuttings became so hot that a thin tongue of red-hot metal flowed away from under them, and when cool they assumed a deep blue colour. In some cases the surface of the turnings was even partially fused. The steel is prepared by a special process of tempering and heat treatment, of which details are not available.

Results* of tests of tools treated by the so-called Taylor-White process have been published.

Reheating Furnace.—In a new form of furnace, designed by Wellman, Daniels, & Wellman to supersede the soaking-pit, the ingots are charged vertically into a long furnace in which they are pushed towards the hot end. They rest on water-cooled pipes, and are prevented from falling over sideways by similar pipe guides. The furnace is thus intended to be of the continuous type.†

At the Kulebaki Ironworks, Russia, a reheating furnace for ingot iron sheets has been erected by J. O. Rayner.‡ Of this a description and illustrations are now given.

Steel for Cycles.—D. Flather§ describes the manufacture and treatment of steel used for cycle construction. The harder kinds of steel require proper annealing, and for good results much depends on the temperature. It should be done on a rising, not on a falling temperature. Too frequent annealing is, however, objectionable. More mechanical work should be put into the steel to improve its quality.

Wire Rope.—Justin S. Doe|| discusses the uses, abuses, and care of wire rope.

Tube-Making.—The Perrin process for making welded tubes is described.¶ Puddled bars of trough section are produced and piled together into a tubular form, with the longitudinal abutting edges

* *Engineering Record*, August 4, 1900; *American Manufacturer*, August 16, 1900.

† *American Manufacturer*, vol. lxvi. pp. 281-282.

‡ *Stahl und Eisen*, vol. xx. pp. 472-474, with four illustrations.

§ Paper read before the Cycle Engineers' Institute; *Ironmonger*, July 7, 1900, p. 9.

|| *Mines and Minerals*, vol. xx. pp. 525-526.

¶ *Iron and Coal Trades Review*, vol. lxi. p. 516.

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construction materials used in it, are given by Frahm.* Details are also given as to the mechanical tests such materials were required to withstand, and a large number of the results of such tests are tabulated. The mode of erection of the bridge is also given.

The re-bridging of the Tugela by the Patent Shaft and Axle Company in an extremely short time is also referred to by Frahm.†

Armour.—An illustrated description of the manufacture of guns and armour at the Bethlehem Steel Works has been published.‡

A review of the progress in the manufacture in the different countries has been issued,§ and some notes on the development of armour for naval purposes have been published,|| the various forms and qualities of armour, and the cost at which it has been supplied at different periods being discussed.

A recently published memoir of H. A. Harvey by his sons¶ traces his connection with the armour plate industry and with numerous other manufactures in which he was a fertile inventor. Some illustrations are given of the first plates tested, and an account is given of the process of face hardening and of its adoption in various countries.

Gun Manufacture.—E. Goffe** gives some notes on the construction of "Long Cecil," a 4·1 breech-loading gun, in Kimberley during the siege, 1899–1900. The tube was bored from a billet of hammered mild steel 10½ inches in diameter and 10 feet long, intended for shafting, and was strengthened by shrunk-on rings made from bars of 6 by 2½ inch Low Moor iron.

J. Castner†† describes the methods in use in Krupp guns for fastening the breech. Such fastenings are in principle based on either the use of the wedge or of the screw. Numerous modifications of both are described and illustrated.

Mention is made ‡‡ of the various arsenals of China, and in particular

* *Stahl und Eisen*, vol. xx. pp. 892–899, 942–947.

† *Ibid.*, pp. 320–322, with one illustration.

‡ *Scientific American*, May 19, 1900.

§ *Engineering*, vol. lxi. pp. 435–438.

|| *Iron and Coal Trades Review*, vol. lx. pp. 685–686.

¶ A copy of this work has been presented to the Institute Library.

** *Institution of Mechanical Engineers' Proceedings*, June 1900, pp. 359–374, with three plates.

†† *Stahl und Eisen*, vol. xx. pp. 570–582, 647–653, with 28 illustrations.

‡‡ *Frankfurter Zeitung*; *Stahl und Eisen*, vol. xx. pp. 864–865.

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PHYSICAL PROPERTIES.

Definitions of Pig Iron, Wrought Iron, and Steel.—A note by A. Pourcel * discusses the definitions of pig iron, wrought iron, and steel. Pig iron is the raw material from the blast-furnaces, and cannot be forged except in the form of malleable castings. Steel and wrought iron contain less carbon, and have a melting-point between 1200° and 1500° C. Differences in the carbon contents, in the power of hardening by quenching, in the method of manufacture by welding and fusion, and in the tensile strength, have been used alone or in combination as the basis of a definition. In practice the most usual mark of differentiation depends on the method of manufacture, wrought iron being considered as welded material and steel as cast metal.

The Crystallography of Iron.—A comprehensive treatise on the crystallography of iron has been written by F. Osmond.† Full accounts of the work of earlier observers are given, the references in each case being appended and their illustrations often being reproduced. The definition of a crystal and of the crystallised state is first discussed, and then follows an account of the facts which may serve in determining the crystallography of *gamma*-iron. These are classified in five groups:—(a) The existence of crystals formed during the solidification of the mass in the cavities of ingots or castings of steel and cast iron; (b) the structure of quenched steel; (c) the structure of manganese steel; (d) the structure of nickel steel; (e) the structure of iron and its alloys in the range of stability of *gamma*-iron, as revealed by etchings conducted at the proper temperature. The observations on steel and iron recorded under the first of these headings all tend to prove that *gamma*-iron crystallises in the cubic system, assuming preferably the shape of the octahedra, more or less

* Paris Congress on Mining and Metallurgy.

† *Annales des Mines*, vol. xvii. pp. 110-165; translated in the *Metallographist*, vol. iii. pp. 181-219, 275-290.

shows a kind of pearlitic structure of rounded grains with intermediate white areas.

H. Le Chatelier has drawn up a report on the present state of knowledge concerning the allotropic modifications of iron and steel for presentation at the Paris International Congress on Applied Chemistry. The various points of transformation are described, and the microstructure of the metals is discussed.

Magnetic Properties of Iron and Steel.—L. M. Potts * has investigated Rowland's method for determining the loss due to hysteresis. Its advantage is that small samples may be used.

S. W. Richardson and L. Lownds † describe experiments that have been made to ascertain in what way the hysteresis loss between given limits of the field strength is connected with the temperature for an alloy containing 3·64 per cent. of aluminium. The experiments show that the hysteresis loss attains a maximum value at a temperature considerably higher than the temperature of maximum induction. The changes produced in the magnetic properties of the alloy by heating and subsequent cooling have also been investigated. The properties depend largely on the previous history of the specimen; but there does not appear to be any essential difference between the behaviour of the alloy during heating and cooling except near the temperature of maximum permeability. Experiments have also been conducted on the abrupt change in the permeability that takes place at a temperature of about 650° C. The conclusions arrived at are as follows:—(1) The hysteresis loss at first diminishes as the temperature rises; it then increases and reaches a maximum at about 550° C.; on further heating it falls off rapidly, and is negligible at 700° C. (2) The magnetic properties of the specimen depend largely on its previous history. (3) There is no essential difference between the behaviour during heating and cooling except near the temperature of minimum permeability. (4) An abrupt increase in the permeability takes place at about 650° C. during heating, followed by an equally abrupt diminution on further heating. (5) This abrupt change is more marked with falling than with rising temperatures. (6) Continued heating and cooling diminish the permeability. (7) The curve connecting temperature of minimum permeability and percentage of aluminium

* *American Journal of Science*, vol. x. pp. 91-114.

† *Engineering*, vol. lxi. p. 796.

and chemical composition of steel. He refers to communications made by himself in 1895 and 1896 to the effect that it was possible to deduce the mechanical properties of steel, as shown by the tensile test, from the chemical composition, formulæ given by him being employed for that purpose. These were based on the assumption that the influence which small quantities of impurities present exert on these properties of iron are alike for equal atomic quantities of all these substances, an assumption which finds an analogy in the behaviour of dilute solutions. The formulæ then proposed were based on carbon 12, silicon 28, and manganese 55, the latter value being rounded off to 56 for the simplification of the equation, when

$$\begin{array}{l} \frac{1}{12} \text{ or } \frac{1}{2} \text{ part carbon,} \\ \frac{1}{28} \text{ ,, } \frac{1}{2} \text{ ,, silicon,} \\ \frac{1}{56} \text{ ,, } \frac{1}{2} \text{ ,, manganese,} \end{array}$$

gave similar effects.

Since, however, one and the same steel gives different results as to tenacity and reduction of area when subjected to different thermal and mechanical treatment, the equation had to be modified, and there is obtained for tensile strength—

$$\begin{aligned} \sigma_B &= A + \frac{1}{2} C + \frac{1}{2} Si + \frac{1}{2} Mn \\ &= A + \Sigma \end{aligned}$$

while for the reduction of area the formula is—

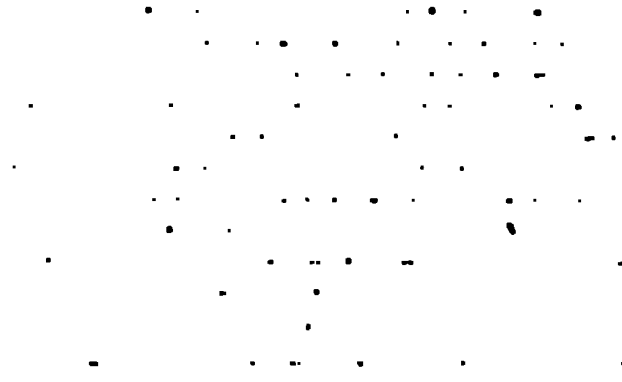
$$\begin{aligned} q &= B - 7 \Sigma \\ &= B - (1\frac{1}{2} C + \frac{1}{2} Si + \frac{1}{2} Mn) \end{aligned}$$

or, simplified—

$$\begin{aligned} q &= B - (47 C + 20 Si + 10 Mn) \\ &= B - \Psi \end{aligned}$$

For one and the same locality and method of production the values of A and B remain fairly constant. For instance, in the case of Neuburg open-hearth steel in its natural unannealed condition, A averages about 2.50 tons and B = 60 per cent. The author shows by a number of testing results that those obtained in actual practice closely agree with those calculated by means of these formulæ; and he observes that he has heard that they are regularly and successfully employed in some German and French works, instead of actual testing. Amongst these are the Peine Ironworks, where a further modification of the formulæ has been made in order to take in phosphorus, its atomic weight for the sake of simplicity being considered as 32. The Peine tenacity formula is consequently—

$$\sigma_B = A + \frac{1}{2} C + \frac{1}{2} Si + \frac{1}{2} Mn + \frac{1}{16} P.$$



The first part of the document discusses the importance of maintaining accurate records of all transactions, including sales, purchases, and expenses. It emphasizes the need for a systematic approach to record-keeping, such as using a ledger or accounting software, to ensure that all financial data is properly documented and organized.

The second part of the document focuses on the importance of regular financial review and analysis. It suggests that businesses should conduct monthly or quarterly reviews of their financial statements to identify trends, assess performance, and make informed decisions about future operations. This process involves comparing actual results against budgeted figures and identifying areas for improvement.

The third part of the document addresses the importance of maintaining accurate cash flow records. It highlights the need to track all cash inflows and outflows, as well as the timing of these transactions, to ensure that the business has sufficient liquidity to meet its obligations. This involves maintaining a detailed cash flow statement and regularly reconciling it with bank statements.

The fourth part of the document discusses the importance of maintaining accurate tax records. It emphasizes the need to keep detailed records of all income, deductions, and credits, as well as the timing of these transactions, to ensure that the business is in compliance with applicable tax laws and regulations. This involves maintaining a detailed tax schedule and regularly reconciling it with tax returns.

The fifth part of the document addresses the importance of maintaining accurate inventory records. It highlights the need to track all inventory items, including their quantity, location, and cost, to ensure that the business has sufficient stock to meet customer demand. This involves maintaining a detailed inventory schedule and regularly reconciling it with physical counts.

The sixth part of the document discusses the importance of maintaining accurate payroll records. It emphasizes the need to track all employee wages, taxes, and benefits, as well as the timing of these transactions, to ensure that the business is in compliance with applicable labor laws and regulations. This involves maintaining a detailed payroll schedule and regularly reconciling it with payroll records.

The seventh part of the document addresses the importance of maintaining accurate debt records. It highlights the need to track all outstanding debts, including their amount, due date, and terms, to ensure that the business is in compliance with applicable debt covenants and regulations. This involves maintaining a detailed debt schedule and regularly reconciling it with debt records.

The eighth part of the document discusses the importance of maintaining accurate capital expenditure records. It emphasizes the need to track all capital assets, including their cost, useful life, and depreciation, to ensure that the business is in compliance with applicable accounting standards and regulations. This involves maintaining a detailed capital expenditure schedule and regularly reconciling it with capital asset records.

The ninth part of the document addresses the importance of maintaining accurate equity records. It highlights the need to track all equity transactions, including their amount, date, and terms, to ensure that the business is in compliance with applicable corporate laws and regulations. This involves maintaining a detailed equity schedule and regularly reconciling it with equity records.

The tenth part of the document discusses the importance of maintaining accurate financial statement records. It emphasizes the need to track all financial statements, including their content, date, and preparation, to ensure that the business is in compliance with applicable accounting standards and regulations. This involves maintaining a detailed financial statement schedule and regularly reconciling it with financial statement records.

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"yield point" of a material as the true criterion of its strength, and has rejected the elastic limit as being modified by local yielding. At present two theories are used in the calculation of strength of material.

The first is that the material yields when one of the principal stresses reaches a certain amount. This theory, which was adopted by Rankine and is used by engineers in England and America, is not in accord with recent experiments. The second theory is that the material yields when the greatest strain reaches a certain amount. This was advocated by St. Venant, and is used by engineers on the Continent. Besides these there is a third theory of elastic strength, in which the condition of yielding is the existence of a shearing stress of a specific amount. In the case of a solid bar subjected to torsion, there is a variation in the strain from the axis outwards, and consequently the materials have been used in the form of thin tubes. This allows the application of an internal fluid pressure. The specimens were of steel, copper, and brass, the state of set caused by drawing having been removed by annealing.

The tubes were subjected to (1) torque; (2) torque and tension; (3) tension only; (4) tension and internal pressure; (5) torsion and internal pressure; and (6) internal pressure only. The axial elongation, the twist, and occasionally the circumferential strain, were measured. Towards the end of the experiments observations were made on bending. The results disprove the maximum-stress theory, and are at variance with the maximum-strain theory.

The maximum shearing stress developed and the corresponding shearing strain were comparatively constant throughout the experiments, and no other simple relation between the stresses and strains was even approximately constant. The results of the experiments have been plotted synoptically on a curve, and the several lines have been drawn upon which these points should be according to the various theories. It is readily seen that the points cluster round the line which represents the existence of a specific shearing stress. The author therefore favours the existence of this stress for any material.

Influence of Hardening.—A paper was read by A. Carnot and Goutal* before the Academy of Sciences, in which they give the results of their investigations on the influence of hardening on the state of combination in steel of elements other than carbon. It has

* *Comptes Rendus*, vol. cxxxi. pp. 92-96.

[illegible]

results in practice, both of steel with a percentage of nickel less than 10, and of one with 12 per cent. of nickel.

The next class of nickel steels considered comprises those containing from 20 to 25 per cent. of nickel. Amongst the special nickel steels with more than 10 per cent. of nickel, only those with from 20 to 25 per cent. have found a real industrial application. The large French works make these steels regularly both in open-hearths and in crucibles, and work it up into sheets and plates. Tests of this kind of steel are given. Nickel steel with 25 per cent. of nickel is also used for boiler-tubes, wire, wire-rope, and springs, and the results are given of a number of other mechanical tests of these materials. In consequence of its high price, steel with 25 per cent. of nickel has only found a limited degree of application in practice.

A fourth kind of commercial nickel steel is that with more than 25 per cent. of nickel. Steel containing 36 per cent. of nickel is used with advantage for instruments of precision in the manufacture of watches, &c. Steel containing 44 per cent. of nickel is used in the form of wire in the manufacture of "wire glass" and as a substitute for the more expensive platinum wire in incandescent lamps. The results of mechanical tests of such steels are given. Both the hardened steels with 36 per cent. and with 44 per cent. of nickel showed a silky fracture when broken in the tensile test.

H. Souther * describes the properties and uses of nickel iron alloys, mainly confining himself to abstracts from the recent monographs of Hadfield and Browne.

Experiments by Rudeloff † comprised as a preliminary the examination of nine kinds of commercially pure nickel obtained from different works. These were analysed and subjected to mechanical and physical tests. The three best kinds were used in the subsequent experiments. In preparing the test-pieces, it was found that castings of pure nickel are not sound unless a magnesium addition has been made. From every fusion two ingots were cast, one of which remained as cast whilst the other was hammered out. These latter, without exception, showed cracks. The mechanical treatment did not change the conductivity for heat or for electricity in any marked degree. Nickel containing manganese was found as cast to possess a greater tensile strength and greater elongation than nickel free from manganese. Mechanical treatment increased both ultimate strength and

* *The Mineral Industry*, vol. viii. pp. 438-449.

† *Oesterreichische Zeitschrift für Berg- und Hüttenwesen*, vol. xlvi. p. 408.

cent. of nickel. The first set of alloys, containing up to 0·343 per cent. of carbon and 0·650 per cent. of manganese, resulted in showing that up to 25·84 per cent. of nickel the non-reversible points are above 0° C. From 27·12 per cent. of nickel the point of transformation on cooling is below 0° C., while at 29·94 per cent. of nickel even solid carbon dioxide does not produce the non-reversible point of transformation. This point, if it exists, which does not appear probable, would only show itself in liquid air. With 25·84 per cent. of nickel in the alloy there are two points of transformation existing simultaneously—one reversible and one non-reversible. As the percentage of nickel increases the reversible point rises and the non-reversible one is lowered.

The points of transformation are as follows in the alloys shown :—

| Composition. | | | Points of Transformation. | |
|--------------|-----------|------------|---------------------------|-----------------|
| Nickel. | Carbon. | Manganese. | Reversible. | Non-reversible. |
| Per Cent. | Per Cent. | Per Cent. | °C. | °C. |
| 25·27 | 0·587 | 0·880 | +75 | none at -78 |
| 24·61 | 0·640 | 0·880 | about -25 | none at -188 |
| 21·90 | 0·570 | 0·480 | about -25 | none at -78 |
| 16·05 | 0·535 | 0·828 | none at -188 | |

The reversible transformation-point of these alloys shows itself on cooling by the appearance of extremely feeble magnetism, which increases in intensity as the temperature falls. The three first became distinctly magnetic in solid carbon dioxide. The second was immersed in liquid air, and its magnetic character had still further increased. The addition of carbon here brought out in these specimens their reversible transformation, which is lowered as the percentage of nickel is diminished. None of the alloys of iron and nickel appear to be eutectic in character. Nickel lowers the points of transformation of iron, and iron those of nickel, although it commences by increasing them. The result is that the magnetism of alloys which have not been submitted to the influence of temperature below 0° C. is due exclusively to iron if the percentage of nickel is below 25, and exclusively to nickel if the nickel contents is above 26 per cent. Between 25 and 26 per cent. of nickel the magnetism has disappeared almost entirely at the ordinary temperature, in consequence of the simultaneous depression of the transformation-points of iron and nickel. It may be added that the points of transformation referred to are magnetic ones.

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the copper percentage rose. In tabular form are shown the results of the chemical analysis and of the mechanical test in the case of fifteen tests. The addition of copper raised the tensile strength, sometimes a little, and sometimes considerably. Thus, while the original cast iron had a tensile strength of 19 tons per square inch, the sample containing 4·9 per cent. of copper had a tensile strength of 22·2 tons per square inch. Copper was not found to produce any marked chilling effect. Even 4·9 per cent. of copper left this Swedish pig iron still a "grey" iron when cast, whereas 1·5 per cent. of manganese or 2 per cent. of chromium chilled it completely. The maximum percentage of copper that pig iron will take up completely was found to be 5, both for grey and white irons. The copper makes the pig iron more fluid when molten, and denser when cast, while it tends to increase its strength. Its influence is, however, not very marked, and is at least far less than that of other elements. It does not seem probable that any advantage to foundry practice is to be expected from the use of copper, but, on the other hand, its presence in the minerals to be used in the manufacture of foundry pig iron need not give rise to any apprehension. It is absolutely unnecessary to separate, that is, any oxidised copper ore that may be present.

The author next deals with the influence exerted by copper on malleable iron and steel. It was formerly believed, he observes, that even very small quantities of copper made steel red-short, but the results obtained by various experimenters differed widely from each other, as the author shows. The experiments made at the Russian ironworks under the author's direction showed that iron containing up to 3 per cent. of copper could be readily worked. When containing a considerable percentage of copper the metal was fairly elastic, and when subjected to malleable action behaved like steel rather than iron. Cracks, however, began to show themselves under such treatment. When the percentage of copper reached 4·7, and when the percentage of copper was from 7 to 10, the cracks became so bad that the metal even fell entirely to pieces. Results are given of the mechanical tests of the various samples. The tensile strength and limit of elasticity increased with the rise of the percentage of copper up to 3·20, but somewhat irregularly. There were, however, slight differences in the percentages of the other constituents also present. The original iron had the following percentage composition :—

| C. | Si. | Mn. | P. | S. | Cu. |
|------|------|------|-------|-------|-----|
| 0·10 | 0·09 | 0·14 | 0·023 | 0·034 | 0·0 |

The percentage of copper varied between 0 and 3. Hardening could be done in oil but not in water, but even oil hardened so energetically that the metal became very brittle and crushed in the jaws of the testing machine. The tests made showed that the presence of copper in steel, such as the above, greatly increases this hardening power, but if the metal is annealed at a high temperature and for a long time, the influence of the copper ceases almost entirely to be observable.

Other tests referred to cupriferous weld iron and to the puddling of cupriferous pig iron, and these showed that the copper did not possess any deleterious action on the metal.

A. Ruhfus,* in discussing Lipin's investigation on the influence of copper on steel, points out that the conclusions deduced will be considered by many to be decidedly at variance with their experience in practice; for instance, the statement that red-shortness is not brought about by copper in iron and steel unless there is over 2 or even 3 per cent. of copper present. This conclusion the author considers to be far too general, and not to hold good for ingot iron. His own experience shows that the maximum permissible percentage of copper in ingot iron, which may be present without causing the metal to show signs of red-shortness on rolling, is 0.4, or for steel containing more carbon and manganese 0.5, assuming that phosphorus and sulphur do not exceed 0.05 per cent. If the metal is to be subjected to a welding process the maximum percentage must not exceed 0.3 for ingot iron or 0.4 for steel. Red-shortness is more evident in the heavier ingots from one and the same charge than in the ingots of smaller size, probably due to the fact that liquation phenomena are more likely to take place in the larger ingots than in the more rapidly cooled ingots of smaller size.

The author considers that there are various causes which may explain the difference between the results of Lipin's experiments and those which are observed in practice. Not the least of these lies in the fact that Lipin's experiments were made in crucibles, and under conditions which largely exclude oxidation,[†] the copper being added in the metallic form. Now it is by no means certain that in blast-furnace metal the copper is all present as such, or whether it may not be also in some other form, combined, that is, with oxygen or some other element. Thus the metal from various charges from an open-hearth, to which 0.4 per cent. of metallic copper had been added

* *Stahl und Eisen*, vol. xx. pp. 691-692.

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metal for bridge construction purposes, experiments have been made on an extensive scale, the conclusions drawn from which are given in a report which is signed by J. E. Brik, the chairman, and the sixteen members of the committee.* The committee found the soft metal examined by them to give good results when used for beams, but beams made of harder metal were much less satisfactory. The harder varieties of basic Bessemer ingot metal suffer badly when rivet holes are punched through them, and basic Bessemer metal cannot be considered satisfactory for bridge construction purposes if it has a tensile strength exceeding 4·3 tons per square centimetre. A basic Bessemer iron to be used for such purposes should have a tensile strength lying between the above as a maximum limit and 3·5 tons per square centimetre as a minimum. The rivet holes should be drilled and not punched, and on no account must the metal be subjected to mechanical treatment at a yellow or blue heat. A red heat must always be employed. Other suggestions are also made. The material to be used for rivets should have a good elongation, and a tensile strength varying from about 3·5 to 4 tons per square centimetre. The rivets must not be heated above a bright cherry-red. The riveting should as far as possible be done by machine. Hand-riveting must be performed as quickly as possible, care being taken to avoid injuring the surface of the metal. Two beams made of soft metal were found to possess in the one case the same strength as the original metal possessed, and in the other 93 per cent. of this, while two beams made of harder metal broke when the stress was only 82 per cent. of what the original metal would have withstood. The hard metal is subject to surface injury, and also liable to internal strains.

Mehrtens † points out that the quantity of basic steel produced in the world in 1899 was about 10,500,000 tons, of which Germany alone produced 5,400,000 tons, or more than one-half. Comparing Austria-Hungary with Germany, it is seen that the latter produces nearly 6·5 times as much as the former. Curiously enough, however, while Germany produces 3,800,000 tons of basic Bessemer metal and only 1,600,000 tons of basic open-hearth metal, in Austria 600,000 tons is made of the latter and only 250,000 of the former. The basic Bessemer process was introduced into Austria in 1879, and the basic open-hearth process only in 1886, but by 1890 it occupied the foremost position,

* *Beilage zur Zeitschrift des Oesterreichischen Ingenieur und Architektenvereines*, 1900, No. 17.

† *Zeitschrift des Vereines deutscher Ingenieure*, vol. xxxiv. pp. 880-882.

of the city of London, and the county of Middlesex, from the year 1600 to the year 1700, in which time the city and county were united into one corporation, and the name of the city and county was changed into the name of the city and county of London.

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of the city of London, and the county of Middlesex, from the year 1600 to the year 1700, in which time the city and county were united into one corporation, and the name of the city and county was changed into the name of the city and county of London.

worn and broken rails, of which a number should be subjected to the ordinary falling-weight tests, and selected specimens to tensile and bending tests, the latter being also chemically analysed and examined by the recent methods of photomicrography. A considerable number of rails were tested in the presence of members of the Committee at the North-Eastern Railway Company's works at Gateshead, and at the Lancashire and Yorkshire Railway Company's works at Castleton, near Rochdale, and from them a selection of sixteen rails for further investigation was made by W. C. Unwin and E. Windsor Richards. The Lancashire and Yorkshire and North-Eastern Railway Companies supplied specimens of the chosen rails cut in a suitable manner for the further investigations proposed, which were apportioned amongst members of Committee as follows:—Mechanical tests, W. C. Unwin; chemical analysis, T. E. Thorpe; photomicrographic examination, Sir W. Roberts-Austen; atmospheric corrosion tests, W. R. Dunstan. W. C. Unwin gives the result of transverse, hardness, and tension tests on each of the selected rails, and also Tetmajer's and Dormus's coefficients of quality for each rail. T. E. Thorpe gives an analysis of each of the sixteen selected rails, and also of the rail, the fracture of which on the Great Northern Railway at St. Neots in December 1895 led to the appointment of the Committee, together with a summary of the methods employed in his analysis. Sir William Roberts-Austen describes the method of examining the rails by photomicrography, the effect of the various constituent elements, and the manner in which they may combine; he also compares the mechanical, chemical, and photomicrographic results of the experiments on the selected rails. His examination of the St. Neots rail disclosed the presence of patches of martensite in portions of the rail, and in order to ascertain whether this, the characteristic constituent of hardened steel, can be produced by other means than by quenching the steel from a high temperature, Sir William Roberts-Austen has examined a portion of the tube of a 4·7-in. quick-firing gun, making a study of the nature of the change produced by the action of the explosive. He is satisfied that the conditions which prevail in the gun do produce changes in the steel which resemble the local changes in structure of the St. Neots rail, but do not enable the local patches of martensite occurring in this rail to be attributed to any other known cause than the quenching of the steel from a high temperature. The structure of this rail is evidently abnormal. W. E. Dunstan gives an account of the manner in which atmospheric

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measure on its structure, which may, if the specimens of steel have been suitably prepared, be revealed by the microscope. The peculiar structure of the St. Neots rail, for instance, can be exactly imitated.

W. C. Unwin, with the assistance of Sir Benjamin Baker and W. Kennedy, prepared a memorandum reviewing from the mechanical point of view the information before the Committee. In this memorandum the following conclusions are arrived at:—(a) The preponderance of fractures near the ends of rails seems to show that the greater straining action due to discontinuity at the joint is a contributing cause of fracture, and this can be remedied by adopting rails of sufficient strength with webs of ample thickness and secure types of fastening, and by care that no looseness arises in service. The fact that worn rails are improved in strength and ductility by annealing proves that part of the deterioration of rails in service is of the nature of what is sometimes termed "fatigue." It appears certain that in some cases fractures of rails have been due to fissures formed during service. How far the minute transverse fissures, very often noticed in the running surface of old rails, give rise to these larger induced flaws requires further investigation. It is not likely that they usually spread into the substance of the rail, because they are common in old rails, and fractures would be more frequent than they are if that were the case. Also, the evidence as to the existence of visible flaws or defects in the fractured surface of rails is very conflicting. In some cases, undoubtedly, the combined effects of the weakening of a rail by wear and corrosion, possibly also increased straining action from defective packing of sleepers, and the presence of a flaw or fissure of not inconsiderable size have led to fracture of the rail. That such defects appear most commonly in the head of the rail is evidence to a certain extent that they are induced by the hammer-hardening of the top surface; (d) it is very desirable that the mechanical tests to which rails are subjected should be as far as possible standardised in connection with (1) the weight, (2) the section, and (3) the chemical composition of the rail.

With these conclusions the Committee agree, and as regards chemical composition they do not think it desirable to insist upon too high a proportion of carbon, manganese, or silicon in the steel, having regard to the ordinary contingencies of manufacture, and the greater susceptibility of high carbon steel to thermal influences.

At the International Railway Congress, held at Paris in 1900, the question of specifications for railway rails was dealt with at con-

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1. *Journal of the American Medical Association*, 1997; 278: 1039-1044.

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1. *Journal of the American Medical Association*, 1997; 278: 1039-1044.

10. *Journal of the American Medical Association*, 2000; 284: 2689-2694.

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maker, and an observer of the wear of rails of many sections and diverse chemical composition, he was led to advocate—(1) that work after careful heating of the steel should be continued until the temperature had been much reduced; and (2) that the carbon percentages should be increased in proportion to the increase of rail section, the ultimate amount being of necessity limited by the contained percentage of phosphorus.

A. L. Colby* reviews the requirements of rail specifications as compared with those proposed for the standard American specifications proposed at the International Congress of the Association for Testing Materials. In forty-one instances the material is specified in eight cases, the carbon in 63 per cent., phosphorus and sulphur in 32 per cent., and silicon and manganese in about half. All prescribe a drop test, and 70 per cent. give a dead weight test. Finish, inspection, and other matters are also referred to.

In continuation† of the discussion W. R. Webster refers to the carbon limits and the finishing temperature; and Sir Lowthian Bell gives the results of a number of drop tests on steel rails made from the top, middle, and bottom of ingots, together with full analysis. The fractures took place at an average fall of 48·9 feet for tops, 64·5 feet for middles, and 77 feet for the bottoms; but the analysis showed only very slight average differences.

Some notes have been given ‡ on the life of steel rails. In the case of tramways so much depends on the endurance of the paving, and the various kinds are therefore considered in some detail. Railway rails are also considered. It is pointed out that in the case of railways the chief limiting consideration which determines the amount of work that can be obtained from steel rails, or their life, is the thickness of metal that can be worn off the face of such rail with a due consideration to safety; while in the case of tramways or street railways, in which the vehicular traffic runs on the same level as the track, it does not depend so much upon the amount of wear to the rail itself, as on the length of time the street paving on which these rails are laid lasts.

Sections of the rails and their fastenings, as used on the Manchurian railway built under Russian auspices, are given,§ together with the specifications for them, and also for the wheels and couplings.

* *American Society of Civil Engineers, Proceedings*, vol. xxvi. pp. 768-773.

† *Ibid.*, pp. 940-948.

‡ *Engineer*, vol. xc. p. 77.

§ *Iron and Coal Trades Review*, vol. lxi. pp. 73-74.

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culars of tests adopted by the Austrian, Belgian, and German State railways for cast wheels are given. The thermal test of the Pennsylvania Railroad is also given, and in connection with this a paper by G. R. Henderson * is referred to, as advocating a certain percentage of manganese to enable the wheels to endure the test. In America the master car-builders' regular guarantee is for forty-eight months, and all wheels which run over five years may be considered as giving good service. As a result of a study of the analyses of such wheels, below are given what are considered to be the desirable limits for the chemical constituents of wheels:—

| | Per Cent. |
|---------------------------|--------------|
| Graphite | 2·75 to 3·00 |
| Combined carbon | 0·50 „ 0·75 |
| Silicon | 0·50 „ 0·70 |
| Manganese | 0·30 „ 0·50 |
| Sulphur | 0·05 „ 0·07 |
| Phosphorus | 0·35 „ 0·45 |

By comparing the above with the analyses of a large number of wheels it was found that these limits excluded those which broke through the rim in ten minutes or less under the thermal test; broke with twenty blows or less under the drop test; or gave less than two years' service. In analyses of seven wheels, which had given from eight to eleven years' service, the following were the limits:—

| | Per Cent. |
|---------------------------|--------------|
| Graphite | 2·56 to 3·10 |
| Combined carbon | 0·63 „ 1·01 |
| Silicon | 0·58 „ 0·68 |
| Manganese | 0·15 „ 0·27 |
| Sulphur | 0·05 „ 0·08 |
| Phosphorus | 0·25 „ 0·45 |

Tests of Armour Plates.—Illustrations are given † of one of two armour plates made by a special process at the Manchester Works at Oppenshaw, and tested at Whale Island, July 3, 1900. It endured five blows from 100-lb. Holtzer projectiles, with striking velocities of 1970 to 2047 foot-seconds, and striking energies of 2691 to 2841 foot-tons. All the projectiles were broken up. The deepest penetration was 2½ inches and surface scaling only was produced. The plate was 8 by 6 feet and 6 inches in thickness.

Particulars have appeared ‡ of some plates made at Terni, and tested at Muggiano near Spezia. One plate, tested on May 3, 1899,

* *Transactions of American Society of Mechanical Engineers*, vol. xx. pp. 615-628.

† *Engineer*, vol. xc. p. 335.

‡ *Ibid.*, p. 7.

CHEMICAL PROPERTIES.

The Influence of Hydrogen on Iron.—E. Heyn * observes that the experiments of Müller and of Stead showed that when holes are drilled in steel ingots gas is evolved, and that this consists chiefly of hydrogen. As this is not the gas that would have seemed likely to have been present, it would appear that some affinity must exist between iron and hydrogen to cause this selection of the latter gas by the iron. The behaviour, too, of solid iron towards hydrogen points in the same direction. Although most of the hydrogen is given up by ingot metal just before it solidifies, yet some will be found in every ingot iron even after annealing and rolling. The cooling curve of electro-deposited iron given by Roberts-Austen forms a further marked advance in our knowledge of this subject. This metal had the hardness of fluor spar, and at 70° evolved considerable quantities of hydrogen. Further quantities were given off at higher temperatures *in vacuo*, and never entirely ceased, though after a temperature of 1300° C. had been exceeded it was but very small in quantity. After dealing with this at further length, the author describes experiments made at Charlottenburg with various kinds of iron which were heated in an atmosphere of hydrogen. One of these, No. I., was soft basic open-hearth rolled metal of the composition:—

| C. | Si. | Mn. | P. | S. | Cu. |
|------|------------|------|-------|-------|------|
| 0·05 | under 0·01 | 0·37 | 0·069 | 0·046 | 0·03 |

Another (II.) was a basic Bessemer beam metal of unknown composition; a third sample (III.) was a soft wire of ingot iron extremely low in carbon, and a fourth (IV.) was a hard ingot metal wire containing 0·37 per cent. of carbon. Nos. III. and IV. were of Westphalian origin. The experiments are described. They showed that if ingot iron is heated in hydrogen at temperatures between 730° and 1000°, and then hardened, the metal is much harder than it would

* *Stahl und Eisen*, vol. xx. pp. 837-844.

durable. In wrought iron and steel the cinder and the cementite respectively have a twofold action, one preventative, resisting oxidation, and the other electro-chemical, which, by the difference of potential, may sometimes hasten and sometimes retard oxidation. The resultant of these actions will vary both with the attacking medium and also with the progress of the action. The author has in progress a large number of experiments, but the following table summarising the results already obtained shows the relative corrosion of soft steel, wrought iron and nickel steel, taking wrought iron as a standard :—

| | Sea Water. | Fresh Water. | Weather. | Average. |
|-------------------------------------|------------|--------------|----------|----------|
| Wrought iron | 100 | 100 | 100 | 100 |
| Soft steel | 114 | 94 | 103 | 103 |
| 3 per cent. nickel steel | 83 | 80 | 67 | 77 |
| 26 per cent. nickel steel | 32 | 32 | 30 | 31 |

D. H. Maury * discusses the electrolysis of underground metallic structures, especially in relation to pipes and rails affected by electric currents. Numerous illustrations are given to show the effects of corrosion thus produced. It would seem that the only way of preventing the corrosion is to keep the currents out of the ground by using return conductors properly insulated on all electric tramways.

M. Rudeloff † discusses the degrees of resistance to a rusting action shown by the wires of wire ropes. The results are given of numerous experiments relating to this. It was found that rusting did not affect the mechanical properties of the unrusted metal remaining in the wire. With regard to the influence exerted by variations in the composition of the metal forming the wires on the way these rusted, it was found that, despite variations in the percentage of manganese, carbon, and phosphorus in the metal forming the series of wires tested, and despite of very differing degrees of mechanical treatment, they were practically equal in their resistance to a rusting action. Rusting diminishes the elongation of the metal, and this diminution is relatively the greater the greater the degree of elongation of the metal before rusting. The tensile strength is also diminished, and the degree, as also in the case of the elongation, appears to be pro-

* Paper read before the Water Works Association, Richmond, Virginia, 1900, through the *Engineering News*, vol. xlv. pp. 38-42.

† *Mittheilungen aus den Königlichen technischen Versuchsanstalten zu Berlin*, Part iii. pp. 107-129.

the first of these is the fact that the system is not self-sufficient. It is necessary to import a large quantity of raw materials and components from abroad. This is a serious disadvantage, especially in the case of a country like India, which is a net importer of foreign exchange. The second disadvantage is that the system is not very flexible. It is not easy to change the design or the specifications of the product without incurring a large cost. This is a serious disadvantage, especially in the case of a country like India, which is a net importer of foreign exchange. The third disadvantage is that the system is not very reliable. It is not easy to maintain the system in good working order. This is a serious disadvantage, especially in the case of a country like India, which is a net importer of foreign exchange.

Disadvantages of Foreign Investment

The first disadvantage of foreign investment is that it is not self-sufficient. It is necessary to import a large quantity of raw materials and components from abroad. This is a serious disadvantage, especially in the case of a country like India, which is a net importer of foreign exchange. The second disadvantage is that the system is not very flexible. It is not easy to change the design or the specifications of the product without incurring a large cost. This is a serious disadvantage, especially in the case of a country like India, which is a net importer of foreign exchange. The third disadvantage is that the system is not very reliable. It is not easy to maintain the system in good working order. This is a serious disadvantage, especially in the case of a country like India, which is a net importer of foreign exchange.

The Importance of Foreign Investment

The first importance of foreign investment is that it is a source of capital. It provides a large amount of money which can be used to finance the development of the country. This is a serious advantage, especially in the case of a country like India, which is a net importer of foreign exchange. The second importance is that it is a source of technology. It provides a large amount of knowledge and experience which can be used to improve the quality of the product. This is a serious advantage, especially in the case of a country like India, which is a net importer of foreign exchange. The third importance is that it is a source of employment. It provides a large number of jobs for the people of the country. This is a serious advantage, especially in the case of a country like India, which is a net importer of foreign exchange.

Conclusion

The first conclusion is that the system is not self-sufficient. It is necessary to import a large quantity of raw materials and components from abroad. This is a serious disadvantage, especially in the case of a country like India, which is a net importer of foreign exchange. The second conclusion is that the system is not very flexible. It is not easy to change the design or the specifications of the product without incurring a large cost. This is a serious disadvantage, especially in the case of a country like India, which is a net importer of foreign exchange. The third conclusion is that the system is not very reliable. It is not easy to maintain the system in good working order. This is a serious disadvantage, especially in the case of a country like India, which is a net importer of foreign exchange.

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and sells for seven times as much as the highest priced ordinary tool steel. It is conceded to be the best steel made for machine tools. It does not twist in hardening, is easy to forge, file, or tool, and machines may and should be driven at a speed far in excess of any that can be used with any other steel. Tungsten steel has marked magnetic properties. The production of the metal to-day in the world does not exceed 1000 tons, and the demand exceeds the supply. Some particulars of the Nova Scotian deposits were given by C. A. Meissner, including the following analysis:—

| | Per Cent. |
|-----------------------------|-----------|
| Tungsten trioxide | 66.32 |
| Silica | 6.25 |
| Manganese | 12.02 |
| Iron | 0.12 |

In the case of the real wolfram the percentage of iron is much higher, and this tungsten ore must rather be called a hibrenite. It is a difficult ore to mine, occurring in bunches in the vein, which itself twists about in an extraordinary manner. Deposits are worked in Germany, Bohemia, and Texas, and it has recently been found in Nevada. It also occurs in the Cornish tin mines.

Iron Selenides.—According to H. Fonzes-Diacon* the combination of iron and selenium at high temperatures always gives rise to compounds containing an excess of selenium over that indicated in the formula FeSe . Amorphous products only are obtained by the action of hydrogen selenide or selenium vapour on red hot iron. Ferric selenide, Fe_2Se_3 , produced by the action of hydrogen selenide on ferric oxide heated to bright redness, forms a grey, micro-crystalline powder with a blue reflex.

The selenides Fe_3Se_4 and Fe_7Se_8 are obtained in a similar manner from the peroxide or anhydrous ferric chloride at somewhat higher temperatures; these compounds are crystalline, and belong apparently to the cubic system.

Iron diselenide, FeSe_2 , prepared in a similar manner in a dull red heat, forms pseudomorphs after crystallised anhydrous ferric chloride; when heated in a current of oxygen, it is oxidised to ferric oxide and selenium dioxide.

The higher selenides are all converted into the monoselenide by reduction with hydrogen; the subselenide Fe_2Se , however, could not be

* *Comptes Rendus*, vol. cxxx. pp. 1710-1712; *Journal of the Chemical Society*, vol. lxxviii. p. 546.

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CHEMICAL ANALYSIS.

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I.—ANALYSIS OF IRON AND STEEL.

The Atomic Weight of Iron.—T. W. Richards and G. P. Baxter* have made a preliminary series of seven determinations of the atomic weight of iron by reducing ferric oxide to metallic iron. Their results seem to show that the generally accepted figure, 56, is slightly too high, and that the true value is very near 55.88.

Statement of Analysis.—H. S. Washington† makes a plea for uniformity in the order of stating the constituents determined in analyses of rock, and gives a list which it is proposed should be followed.

The lack of uniformity applies not only to rock analysis, but to all other analyses, and a general system of uniformity in each particular case would be very advantageous.

A Bibliography of Steelworks Analysis.—H. Brearley‡ has continued the publication of his bibliography of steelworks analysis. All the papers relating to the subject published in the Journals of the Iron and Steel Institute, the Chemical Society, and the Society of Chemical Industry are classified and briefly abstracted.

* *Proceedings of the American Academy of Arts and Sciences*, vol. xxxv. No. 13; *Chemical News*, vol. lxxxi. p. 174; *Zeitschrift für anorganische Chemie*, vol. xxiii. p. 255.

† *American Journal of Science*, vol. x. pp. 44-54.

‡ *Chemical News*, vol. lxxxi. pp. 49, 64, 76; vol. lxxxii. pp. 6, 18, 26, 42, 180, 185, 197.

Micro-Chemical Analysis.—A recent article * discusses the use of micro-chemical methods of analysis as adapted to iron and steel. They are given as quantitative only, but are of extreme delicacy, and capable of detecting very minute traces of silicon, tungsten, sulphur, manganese, chromium, nickel, cobalt, and copper. It is possible, however, that they may be used to some extent as indicating the quantities present. The methods are described in some detail. For silicon the metal is dissolved in nitric acid, and the solution is heated in a platinum spoon with sulphuric acid until the residue is nearly dry. Ammonium fluoride is then added, with a small drop of water, and the spoon is covered with a similar platinum spoon which has been cooled by water. Sublimation is then carried out, the sublimate being received on the moistened spoon. By this means hydrofluosilicic acid is formed, which on the addition of sodium chloride forms sodium fluosilicate. This salt crystallises on a varnished slide in characteristic hexagonal plates and stars, and in more concentrated solutions in elegant six-rayed rosettes, with a faint rose tint and sharp outlines. Phosphorus is shown as phospho-molybdate, and the remaining solution will show very minute traces of silicon as a rubidium silicomolybdate with the use of proper reagents. Sulphur is shown by the formation of crystals of sulphate of calcium or of lead, manganese as oxalate, chromium as chromate of silver or lead, tungsten as thalious tungstate, cobalt as the double nitrate of potassium and cobalt, and both nickel and copper are best seen in the triple nitrates with lead and potassium.

Determination of Carbon.—B. Blount† has made experiments to ascertain whether the carbon in steel can be determined by the direct combustion of the steel filings. He found that if the filings without further subdivision are placed in a porcelain tube heated by a Fletcher burner to 700° or 800° C., and a current of oxygen is passed over them, the combustion of the carbon commences at a rapid rate, but that an oxide layer soon forms on the steel which prevents the further oxidation of the carbon. The author then used a flux, such as lead oxide, to remove this oxide film, but the results were unsatisfactory in that no tube used would resist the action of the litharge. If, however, the steel was raised to a temperature of 1100° to 1200° C., the combustion of the carbon in from 3 to 5 grammes of filings is com-

* *Colliery Guardian*, vol. lxxx. pp. 267-269.

† *The Analyst*, vol xxv. pp. 141-144.

pletely effected, and that within the space of an hour. Metallic iron particles will be left, but they are quite free from carbon. Here again, however, the tubes offer difficulties. They will not stand the high temperature for long, and frequently fracture during the experiments. Heating in oxygen even to 1200° C. does not enable the sulphur to be determined. A portion is burnt out, but more than 20 per cent. remains in the iron. The peculiarity of "kernel roasting" is observed in this case, the sulphur segregating into the iron kernel.

F. Ibbotson * and H. Brearley give some methods for the analysis of tungsten compounds. Carbon is determined by ignition with oxides of lead.

George W. Sargent † describes a modification of the ordinary process of burning the carbonaceous residue of iron and steel in a current of air or oxygen. The air or oxygen employed is first passed over a red-hot spiral made from a platinum tube 17 inches long and 5.32 inches in diameter. This gives four close coils $\frac{3}{4}$ inch in diameter, and leaves 4 inches extended on either side. The object is to fully oxidise any hydrocarbons which may be present in the air, and the carbon dioxide formed is then absorbed in a Geissler bulb apparatus. The carbon is placed in a porcelain boat heated inside a porcelain combustion tube and the resulting gases are passed through a tube containing red-hot copper oxide to ensure complete oxidation. It has been found that the same object is attained by passing the gases through a small glass tube in which two platinum wires were fused, so that a spark would be produced between the points, when a current from a Rhumkorff coil passed through the wires. As there is, however, always a danger of stoppage, the use of copper oxide is the safest. To retain traces of hydrochloric acid or chlorine, the gases are afterwards passed through a $\frac{1}{2}$ -inch glass tube 6 inches long, containing loosely packed coarse wet sand held in place by two small discs of copper gauze placed at either end.

Precautions are taken to prevent overheating of the corks. The dried gases are then finally absorbed in a weighed Geissler apparatus of somewhat larger size than usual, and containing 30 cubic centimetres of aqueous caustic potash of 1.27 specific gravity.

G. Auchy ‡ discusses the Dougherty method for the determination of carbon in steel. In this method the carbon sponge is first washed

* *Chemical News*, vol. lxxx. p. 293.

† *Journal of the American Chemical Society*, vol. xxii. pp. 277-285.

‡ *Ibid.*, pp. 334-343.

sample in 45 c.c. 1·20 nitric acid, add permanganate until a pink colour or a manganese oxide precipitate persists after a few minutes' boiling, clear with ferrous sulphate, add about 4 c.c. strong ammonia, and then to the clear hot solution 30 c.c. of the molybdate reagent. Shake the stoppered flask, allow to stand a few minutes at 70° to 80° C., pass through a small pulp filter, wash, dissolve off yellow precipitate with a few drops of ammonia, clearing the sides of the flask with the same solution as it drops from the end of the funnel, pass solution again through the filter into a small beaker (200 c.c.), and wash. Add 10 to 12 c.c. hydrochloric acid, 10 c.c. lead acetate (40 grms. per litre), and heat. In the washed-out flask heat a mixture of ammonium chloride (= 10 to 12 grms. NH_4Cl) and 50 c.c. strong ammonium acetate; mix the two solutions in the flask with shaking, filter, and weigh as PbMoO_4 . The weight multiplied by 0·007 gives the weight of phosphorus in the steel. The operation is very conveniently performed with batches of four, which are completed in an hour and a half. A single estimation takes about forty minutes.

Some noteworthy features of the process are :—The PbMoO_4 is quite insoluble in the solutions used; being very granular it filters well, and it can be ignited speedily without loss of weight, and it weighs more than one hundred and forty times heavier than the phosphorus to be estimated.

Determination of Silicon.—H. Bornträger* finds that the solution of ignited ferric oxide in hydrochloric acid is more easily effected by adding some manganese dioxide. Apparently this is due to the chlorine liberated.

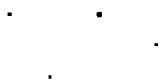
F. W. Bauer† gives the variations by six different methods of determining silicon in ferro-silicon as ranging from 15·17 to 16·25 per cent. Direct fusion with sodium carbonate gives the lowest results.

Determination of Sulphur.—M. J. Moore,‡ in connection with the supposed gain of sulphur in malleable castings after annealing, refers to the influence of treatment of the metal on the method of determination. When the evolution method is followed, the sulphur sometimes passes off in a form not soluble in the absorbent, and so escapes estimation. A number of results are given to show the

* *Zeitschrift für Analytische Chemie*, vol. xxxviii. p. 774.

† *Iron Trade Review*, May 31, 1900, p. 20; *Iron Age*, May 31, 1900, p. 11.

‡ *Iron Age*, May 3, 1900, pp. 25–26.



methods in which inorganic acids are used in the solution of the steel. Such acids dissolve slag as well as metal. Even very dilute acids, the author finds, dissolve considerable quantities of slag. Thus when slag which had been squeezed out of a puddled rail was treated with water containing 5 per cent. of nitric acid, 58 per cent. of the slag passed into solution. A portion of the slag, however, resists the action of even strong nitric acid. Thus samples of iron that contain slag leave some of this slag undissolved after treatment with a mixture of one part of nitric acid with two parts of water. Hydrochloric acid exerts a still stronger solvent action.

To the second group of methods, giving results that are too high, belong the Eggertz methods so frequently employed. These consist in principle of dissolving the iron by bromine or iodine in the presence of water, the slag being left as a residue. The author has shown that phosphides of iron and manganese may also be found in the residue left after treatment with copper chloride. Iodine and bromine also give different results. Thus P. R. von Mertens found in the same sample of weld iron 0.93 per cent. of slag when bromine was used as the solvent, and 2.02 per cent. when iodine was employed. The author has obtained similar results. The residue after the use of iodine contained particles of iron. Even when bromine is used, such metallic particles may be left, as the author shows in the cases of four samples of steel. The residues left were all high in phosphorus—in one case to the extent of 14.2 per cent. Of all the customary solvents, bromine is the one that acts most strongly on those metallic compounds occurring in iron and steel that are difficult to dissolve. Its action, however, is very considerably less energetic if, with the addition of a bromide, it has been brought into aqueous solution. If, for instance, steel is shaken up frequently for several days with a solution of bromine in potassium bromide, a metallic residue will still remain. Well-marked constituents of steel separate out as a fine grey powder. The aqueous solution of bromine in iron bromide also acts somewhat feebly. To make the action complete the solution must be heated. The method which the author recommends is the following:—Place 15 cubic centimetres of bromine, and on this 100 cubic centimetres of water, in a beaker which will hold from 200 to 300 cubic centimetres. Then place this beaker in another containing water, to avoid too rapid an action when the iron commences to pass into solution. Next, charge in five grammes of the sample in some finely divided form, and shake the solution. Continue dissolving in the cooled beaker until no

1. The first part of the paper discusses the importance of the research and the objectives of the study.

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5. The fifth part of the paper discusses the implications of the study.

6. The sixth part of the paper discusses the limitations of the study.

7. The seventh part of the paper discusses the future research.

8. The eighth part of the paper discusses the acknowledgments.

9. The ninth part of the paper discusses the references.

10. The tenth part of the paper discusses the appendices.

be taken from a clean surface. If the filings taken are too small, the smaller particles of slag are readily lost.

The Analysis of Chrome and Tungsten Steel.—A. G. McKenna * describes his methods for the complete analysis of chrome and tungsten steels. Five grammes of the broken sample are dissolved, by boiling, in a 500 cubic centimetre evolution flask with 30 cubic centimetres each of hot water and hydrochloric acid. The gas is passed into ammoniacal cadmium chloride, which is then titrated for sulphur with iodine and starch. To the solution 10 cubic centimetres of strong nitric acid is added, and it is boiled to dryness, taken up with 15 cubic centimetres of strong hydrochloric acid, evaporated, and again taken up with 20 cubic centimetres of the acid, and diluted to 100 cubic centimetres. Silica and tungstic acid are filtered off and washed with 5 per cent. nitric acid and ignited. After weighing, the silica is driven off with hydrofluoric acid, and the remaining tungstic acid is weighed. The filtrate is evaporated to a small bulk, 50 cubic centimetres of acid are then boiled in it to expel hydrochloric acid, and after fumes cease the solution is made up with nitric acid to 200 cubic centimetres; 10 grains of potassium chlorate are added to the boiling solution, which is then evaporated to 75 cubic centimetres. The manganese is thus precipitated as MnO_2 and filtered on an asbestos plug. Chromium is titrated with ferrous sulphate and permanganate in the solution diluted to 500 cubic centimetres. Phosphorus is determined by molybdate in a separate portion from which silica and tungstic acid are separated. Carbon is determined by ignition of the residue left after solution in potassium copper chloride.

Determination of Nickel.—R. Fieber † adopts a colorimetric method for the determination of nickel. If steel containing nickel is dissolved in nitric acid, and the iron precipitated by ammonia, the degree of intensity of the blue coloration of the filtrate is proportional to the percentage of nickel present. The presence of relatively large percentages of chromium interferes with this result. Standard solutions are prepared, which are then used for the purposes of comparison with that resulting from the solution of the steel under examination. To prepare these, 6 grammes of metallic nickel, the percentage of

* *Proceedings of the Engineers' Society of Western Pennsylvania*, vol. xvi. pp. 119-121.

† *Chemiker Zeitung*, vol. xxiv. pp. 393-394.

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molybdenum with sulphuretted hydrogen. The molybdenum sulphide precipitate is washed with a flask with hot ammonium sulphide solution. If any molybdenum sulphide should remain on the filter paper that cannot be removed by hydrochloric acid, the paper must be incinerated, and the residues fused with soda and sulphur. The various solutions containing the molybdenum are mixed together, heated for two or three hours, filtered, again heated nearly to boiling, and then the molybdenum is precipitated by hydrochloric acid of 1.124 specific gravity. The whole is then boiled until no more sulphuretted hydrogen can be detected, and is subsequently filtered through a weighed filter, and dried at a temperature of 120° C. A portion of the precipitate on the filter is subsequently ignited in a current of oxygen until the weight is constant and the molybdenum contents is calculated from the weight of the molybdenum sulphide, MoS_2 , so determined.

The estimation of molybdenum in steel and steel-making alloys is exhaustively discussed by F. Ibbotson * and H. Brearley.

II.—ANALYSIS OF IRON ORES AND SLAG.

Determination of Iron.—L. Blum † considers the question of the determination of iron in tap-cinder. Such determinations made by the permanganate or stannous chloride methods frequently show varying results, due, the author shows, to the almost unfailing presence of vanadic acid. The reducing agents employed reduce the vanadic acid as well as the ferric salt, and it subsequently again oxidises and appears as so much iron in the results. Accurate determinations are only possible by the use of elaborate gravimetric methods. The author dissolves half a gramme of the substance, separates the silica, neutralises with ammonium carbonate, dilutes, and precipitates boiling with ammonium acetate. The precipitate is again dissolved, reprecipitated, washed, dissolved in hydrochloric acid; tartaric acid is added, and the iron is then precipitated by ammonium sulphide. The precipitate is allowed to settle for a considerable time. Vanadium sulphide, phosphoric acid, lime, and alumina remain in solution. The iron sulphide is washed with water containing ammonium sulphide, dissolved, oxidised, precipitated with ammonia, and determined in the ordinary manner. When the cinder itself is fused with potassium-sodium car-

* *Chemical News*, vol. lxxxi. pp. 269-271.

† *Zeitschrift für Analytische Chemie*, vol. xxxix. pp. 156-157.

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Determination of Tungsten.—H. Bornträger* decomposes tungsten ores and residues by fusing one gramme of the finely powdered material for an hour with 10 grammes of calcined soda and heating until the whole is in a state of clear fusion. It is afterwards extracted in the hot, diluted to 250 cubic centimetres, cooled, and filtered. Each 100 cubic centimetres of the filtrate is then equivalent to 0·4 gramme of the substance, and to this quantity of solution there is added 15 cubic centimetres of nitric acid and 45 of hydrochloric acid, and the mixture is then evaporated to dryness in a porcelain dish. The extraction is subsequently made with a solution consisting of 100 grammes of ammonium chloride, 100 grammes of hydrochloric acid, and 1000 grammes of water, then filtered, and the residue washed with hot ammonia. This residue may consist of silica, tungstic acid, and stannic acid. To the filtrate nitric and hydrochloric acids are added and the whole again evaporated to dryness. The tungstic acid so obtained is free from silica and oxide of tin, and after ignition can be weighed direct. If metallic tungsten, containing oxygen, carbon, antimony, iron, and silica is to be analysed, it is ignited for half-an-hour and some nitre then added to the ignited material. Tungsten alloys are treated in a similar way. The author considers that the determination of tungsten by precipitation with mercury leads to very inaccurate results. Commercial tungsten contains from 95 to 97 per cent. of that element.

As the accurate analysis of tungsten ore is a lengthy operation, the author recommends the use of a rapid method which enables the tungstic acid to be very rapidly determined, and gives results that are accurate within 5 per cent. The ores consist of ferrous and manganoous tungstates, rendered impure by sand, lime, magnesia, antimony, tin, lead, cobalt, nickel, and copper. One gramme of the finely divided ore is fused for an hour with 10 grammes of soda, and then extracted, filtered, and weighed. If the weight of the residue is subtracted from 100, the approximate percentage of the tungstic acid is at once obtained.

Analysis of Chrome Iron Ore.—According to R. Fieber,† 0·5 gramme of the finely powdered ore is fused in a platinum crucible with three grammes of sodium potassium carbonate for 10 minutes; when

* *Zeitschrift für Analytische Chemie*, vol. xxxix. p. 306; *Stahl und Eisen*, vol. xx. p. 995.

† *Chemiker Zeitung*, vol. xxiv. p. 333; *Journal of the Chemical Society*, vol. lxxviii. p. 512.

mass is dissolved in water containing 10 per cent. of sulphuric acid, and finally made up to 500 c.c. One hundred c.c. of the filtrate are then mixed with 5 c.c. of hydrogen peroxide, and the colour thus produced is compared with that of a series of ferruginous solutions to which a varying amount of titanium and 5 c.c. of hydrogen peroxide have been added. Iron is estimated by the bichromate method in the filtrate from the silica.

III.—FUEL ANALYSIS.

Apparatus for Determining the Calorific Value.—Gaetano Magnanini and V. Zunino* describe a modified form of Lewis Thompson's calorimeter, in which the use of an oxidising mixture to burn the fuel is obviated, and the combustion carried on in a steady stream of oxygen. A series of fifteen different samples of coal were examined in the new apparatus and good results obtained, the calorific values found being in every case but two higher than the numbers yielded by the Lewis Thompson method.

Determination of Sulphur.—Pellet† deals with the determination of sulphur in coal and other bodies. The material is oxidised by fusion with a mixture of potassium nitrate and sodium carbonate. The aqueous solution is acidified, and the sulphur is precipitated as barium sulphate.

* *Gazetta Chimica Italiana*, vol. xxxi. pp. 395–401; *Journal of the Chemical Society*, vol. lxxviii. p. 465.

† Paper read before the Paris International Congress of Applied Chemistry.

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cussed from a German point of view.* The production, imports, and exports of pig iron are tabulated as follows:—

| Year. | Production. | Imports. | Exports. |
|----------------|--------------|--------------|--------------|
| | Metric Tons. | Metric Tons. | Metric Tons. |
| 1891 | 7,525,301 | ... | 853,580 |
| 1893 | 7,089,318 | 35,923 | 853,391 |
| 1895 | 8,022,006 | 94,609 | 880,433 |
| 1897 | 8,930,086 | 160,531 | 1,219,958 |
| 1899 | 9,454,204 | 174,159 | 1,401,365 |

During the first nine months of 1900 the imports of pig iron into the United Kingdom were 96,077 tons as compared with 144,382 tons in 1899. In this latter year 91 per cent. of these imports came from the United States, Sweden, and Spain. The imports of pig iron from the United States were only 3727 tons in 1895, but as much as 82,284 tons in 1899. The exports to Germany amounted to 348,000 tons in 1897, 292,000 tons in 1898, and 438,000 tons in 1899; while to Holland it was 220,000 tons in 1897, 169,000 tons in 1898, and 266,000 tons in 1899. Of this, most evidently went to Belgium and Germany. Proof of this is obtainable from the fact that the German statistics show that the imports of pig iron from the United Kingdom in 1899 amounted to 530,000 tons, as compared with the 438,000 tons shown in the United Kingdom statistical returns. A marked feature of recent progress in the United Kingdom export iron trade is shown by the increase in the exports of ingots, slabs, &c., the exports of which in the first nine months of 1900 amounted to an excess of 177,443 tons over the imports of similar products. An interesting comparative tabular review shows the exports to the various colonies and to other countries in 1895 and 1899. The special feature in the statistics of recent years is believed to lie in the large increase in the imports of pig iron, semi-manufactures, and other iron trade products from the United States. At the same time the exports from the United Kingdom to the United States have undergone a diminution. Thus, in 1895, 6000 tons of rails were exported, and only 81 tons in 1899, while of tin-plate the exports fell from 225,000 tons in 1895 to 60,000 in 1899, and of pig iron in the same period from 42,104 tons to 36,317 tons, or 14 per cent.

Iron Ore Supply.—A report to the British Iron Trade Association by J. S. Jeans † deals with the iron ore supplies available for the British

* *Stahl und Eisen*, vol. xx. pp. 1077-1080.

† *Iron and Coal Trades Review*, vol. lx. pp. 1192-1194.

exports is considered, and the imposition of an export duty is advocated, as is also the appointment of a Royal Commission.

The threatened exhaustion of Britain's cheap coal supplies is dealt with by J. S. Jeans* in a series of articles, and a number of letters on the British coal resources and exports have been published.† Amongst the contributors are J. B. Simpson, E. Hull, T. Forster Brown, C. H. Vincent, D. A. Thomas, and G. Harwood.

II.—AUSTRALASIA.

Coal in Queensland.—In the Budget statement of the Hon. Robert Philp, Premier and Treasurer of Queensland, it was stated that the production of coal in 1899 was 494,000 tons, being an increase of 80,000 tons over that of the preceding year. Hitherto, the consumption of coal has been purely local; indeed, the mines have been unable to supply the requirements, the reason being the remoteness of the coal-beds from water-carriage. The increased demand for coal all over the world has no doubt been the cause of attention being again directed to the great stores of this article that the Colony possesses, and it seems probable that an effort will be made, not only to supply all local wants, but to look for markets outside the Colony. It is estimated that within the area of the Blair Athol coalfield—about five square miles—there are 7,000,000 tons of the finest quality of Clarmont coal, and about 56,000,000 tons of a slightly inferior quality in a lower seam not yet mined, irrespective of other seams that may exist at greater depths. A remarkable discovery of anthracite coal was lately reported to have been made on the Dawson River. The seam is 11 feet thick, and the coal is very heavy and compact. As the coal country extends westerly from the Dawson for many miles, the quantity of anthracite is enormous. No other coal of the same character has been found in Australia, so that the deposit will be a very material factor in metallurgical operations within the Colonies, and may become of international importance. As to Collide Creek, situate about 50 miles in a south-westerly direction from Gladstone, so long ago as 1892 the Assistant Government Geologist reported that, over the area already proved, there was sufficient

* *Iron and Coal Trades Review*, vol. ix. pp. 931, 977, 1025.

† *Ibid.*, pp. 933, 978, 1028, 1223.

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machinery in use, of the workmen employed, of the accidents that occurred during the year, and of the miners' provident clubs. In all the Austrian mines in 1898 there were 61 winding engines with an aggregate horse-power of 3161, 53 pumping-engines with a horse-power of 3891. There were employed 116,160 men, 6489 women, and 6036 lads. During the year there were ten fire-damp explosions, no miners being killed, but eight being severely and ten slightly injured.

The Iron Industry of Austria.—C. R. von Ernst* considers generally the progress that has been made by the iron industry in the nineteenth century, and in particular the share that Austria has taken in it. The first half of the century is marked by the steady replacement of vegetable by mineral fuel in blast-furnace practice, and in the subsequent treatment of the metal; while in the second half the steady transition from the manufacture of weld iron to that of ingot metal is most marked, and steel has replaced iron. The impulse for each of these changes has come from the United Kingdom. In this country coal was generally employed in iron metallurgy at the commencement of the century, but in all other countries charcoal was in general use, and coke was only employed successfully in Upper Silesia. In the chief iron-producing districts of Austria the conditions were more unfavourable to the use of coal than anywhere else; but notwithstanding this, it came into use at a relatively early date. The largest Austrian furnace was at that time the Egger furnace at Treibach, in Carinthia; those at Rohnitz in Hungary, the Joseph furnace at Reschitza, and the Strimbul furnaces in Transylvania were the largest in Hungary. They varied in height from about 24 feet to 37·5 feet, while the maximum daily out-turn of such a furnace was about $6\frac{1}{2}$ tons. The author compares this out-turn with an out-turn of 720 tons in one day stated to have been obtained at blast-furnace No. 3 of the Carnegie steelworks in July 1898. The first coke blast-furnace in Austria was erected in 1821 at the Sternberg works at Darowa in Bohemia, after experiments by A. Obersteiner had shown that Bohemian coal could be converted into suitable coke. Nine years later the first important coke oven plant was built at Witkowitz, and this really introduced the coke blast-furnace practice permanently into Austria. As the manufacture of coke spread, foundry practice underwent important changes.

* *Zeitschrift des Oesterreichischen Ingenieur und Architekten-Vereines*, vol. lii. pp. 321-322.

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Mineral Statistics of Hungary.—The production of Hungary in the year 1898 included the following, the figures for 1897 being also shown : *—

| | 1897. | 1898. |
|----------------------------|--------------|--------------|
| | Metric Tons. | Metric Tons. |
| Brown coal | 3,863,311 | 4,206,694 |
| Coal | 1,072,549 | 1,239,498 |
| Briquettes | 27,022 | 31,781 |
| Coke | 7,219 | 8,190 |
| Forge pig iron | 402,503 | 448,621 |
| Foundry pig iron | 17,398 | 20,784 |
| Manganese ores | 53 | 65 |

The accidents in the Hungarian mines and works were as follows in the year 1898 :—Collieries, 22 fatal and 51 severe ; brown coal mines, 28 fatal and 83 severe ; iron ore mines, 17 fatal and 27 severe ; iron-works, 2 fatal and 6 severe. The workpeople employed numbered 9581 in the collieries, 20,634 in the brown coal mines, 11,783 in the iron ore mines, and 6498 in the ironworks.†

Mineral Statistics of Bosnia and Herzegovina.—The official statistics for the year 1899 show the mineral production of Bosnia and Herzegovina to have included : ‡—

| | 1899. | Increase or Decrease. |
|----------------------------------|--------------|-----------------------|
| | Metric Tons. | Metric Tons. |
| Iron ore | 67,085 | + 8,552 |
| Chrome ore | 196 | - 262 |
| Manganese ore | 5,296 | - 54 |
| Pig iron | 13,749 | - 1,587 |
| Castings | 1,109 | + 167 |
| Open-hearth ingots | 10,080 | + 1,410 |
| Rolled iron | 9,939 | + 1,428 |
| Charcoal, cubic metres | 105,700 | - 23,512 |

The reduction in the production of pig iron was due to a blast-furnace having undergone rebuilding during the year.

The quantity of brown coal mined during 1899 was 303,425 metric tons, this being an increase of 32,242 tons as compared with the production in 1898. At these brown coal mines 887 workpeople were employed in 1899, as compared with 777 in 1898. At the iron ore

* *Oesterreichische Zeitschrift für Berg- und Hüttenwesen*, vol. xlviii. pp. 170-172.

† *Ibid.*, pp. 159-160.

‡ *Ibid.*, pp. 336-338.

and the profit per ton was 1.59 francs. The output per miner was 233 tons. The greatest depth attained was 3560 feet, at the Produits colliery. The production of coke was 1,670,620 tons, the number of coke ovens in operation being 2947.

Libert* has furnished the Belgian Government with his annual report on the coal-mining industry of the province of Namur. The coal output of the province in 1899 was 641,360 tons, an increase of 28,960 tons over that in 1898. The average depth of the workings is 313 yards. The deepest shaft is the Sainte-Eugenie pit of the Tamines colliery, which is 1771 feet deep. The collieries afforded employment to 3310 persons, of which 2371 were employed underground.

V.—CANADA.

Mineral Statistics.—The mineral statistics of the Dominion of Canada for 1899 † comprise:—

| | Tons. |
|------------------------------|-----------|
| Iron ore | 69,997 |
| Chrome iron ore | 1,796 |
| Coal | 4,142,242 |
| Coke | 91,463 |
| Fireclay | 543 |
| Limestone for flux | 48,265 |
| Manganese ore | 279 |
| Nickel ore | 2,605 |
| Moulding sand | 12,450 |

The production of crude petroleum was 808,570 barrels.

The Iron Industry.—The production of all kinds of pig iron, ‡ including spiegeleisen and ferro-manganese, in 1899 in Canada, was 94,077 tons, of which 17,796 tons were charcoal pig iron. The production of steel ingots was 22,000 tons.

During the Canadian meeting of the American Institute of Mining Engineers, visits were paid to the Dominion Iron and Steel Company's Works in course of erection at Sydney, to the ore deposits at Belle Island, and to the collieries of the Dominion Coal Company, besides other works. The steel plant will draw its metal from four 350-ton furnaces and is intended to produce 1400 tons daily. A by-product coke oven plant to supply coke and illuminating gas is also in course

* *Moniteur des Intérêts Matériels*, vol. 1. pp. 1933-1934.

† *The Mineral Industry*, vol. viii. p. 824.

‡ *Annual Statistical Report of the American Iron and Steel Association*, Philadelphia, 1900, p. 70.

The figures are practically the same as those for the corresponding period of last year.

The French imports and exports * during the first half of this year included :—

| | Imports. | Exports. |
|------------------------|--------------|--------------|
| | Metric Tons. | Metric Tons. |
| Coke | 760,210 | 36,590 |
| Iron ore | 1,049,960 | 186,853 |
| Pig iron | 87,314 | 72,838 |
| Wrought iron | 27,411 | 16,963 |
| Steel | 12,785 | 9,763 |

Iron Ore.—Of the 5,000,000 tons of ore raised annually in France, 4,000,000 are obtained from the minette district, while of the 2·5 million tons of pig iron made, some 1·5 million is obtained from minette ores. The seams of ore reach to about 20 feet in thickness, with from 36 to 42 per cent. of iron. In places this percentage falls to as low as 27. New blast-furnaces are being erected near Nancy, Villerupt, and in the Upper Orme valley, and when these are finished this ore field will have 80 blast-furnaces. Bore-holes which have been put down have proved around Briey at least 2000 million tons of ore. †

The Paris Exhibition.—The Paris Exhibition, from April 15 to November 12, was visited by 50,859,935 persons, 47,076,803 tickets having been used. At the Exhibition of 1889 the number of tickets used was 28,149,352. The Exhibition naturally gave rise to the publication of a large amount of technical literature, to some of which reference has already been made in this volume. The metallurgical exhibits are described in H. Bauerman's paper and elsewhere. ‡

Le Mois Scientifique et Industriel devotes a special section to abstracts of important memoirs dealing with the Paris Exhibition. One of the most interesting articles is that by G. Eude, dealing with the mechanical installations at the Exhibition. Motive power was produced in the form of electrical energy. The most powerful plant of French construction was that made by the Alsatian Company, which has an indicated horse-power of 1200 and a power of 675 kilowatts. The most powerful of the foreign plants was the Willans and Robinson steam-

* *Comité des Forges, Bulletin*, No. 1637.

† *Stahl und Eisen*, vol. xx. p. 845.

‡ *Engineering News*, vol. xlv. pp. 48-49; *Ironmonger*, vol. xcii. July 7, 1900; *Iron and Coal Trades Review*, vol. lx. p. 1228; vol. lxi. Supplement, August 10, 1900.

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and Luxemburg, were as follows in 1899, according to the statistics collected by the *Verein deutscher Eisenhüttenleute* : *—

| | Metric Tons. |
|----------------------|--------------|
| Production | 8,029,305 |
| Imports | 675,793 |
| Exports | 235,194 |

The consumption of pig iron in Germany shows a steady increase since 1891, when it amounted to 4,720,242 tons. In 1899 the consumption was as much as 8,469,904 tons, while in 1884 it was only 3,599,106 tons. In 1894 and 1895 the exports of pig iron from Germany slightly exceeded the imports, but in every other year since 1887 the reverse had been the case.

The present position of the iron industry of Germany is discussed.† The progress made has of recent years been extremely rapid, but of late the enormous production in the United States and the troubles in China have greatly affected the position for the worse, and it seems possible that the iron trade of Germany may suffer seriously. How rapid has been the increase in the production is shown in tabular form. The first table shows the production, consumption, imports and exports of pig iron in the German Customs Union for each of the years 1891–1899. The annual percentage increase in production has been as follows, each year being compared with the preceding one: 6·4, 0·3, 12·2, 4·1, 9·9, 8·3, 7·5, and 8·4. For the years shown the details are as follows :—

| Year. | Production. | Consumption. | Imports. | Exports. |
|----------------|--------------|--------------|--------------|--------------|
| | Metric Tons. | Metric Tons. | Metric Tons. | Metric Tons. |
| 1891 | 4,641,217 | 4,720,242 | 244,256 | 111,154 |
| 1895 | 5,788,798 | 5,768,251 | 188,217 | 135,289 |
| 1899 | 8,029,305 | 8,469,904 | 612,652 | 182,091 |

In the first eight months of 1900 the production has been 5,469,014 tons as compared with 5,367,509 tons in the similar period of the previous year. This is an increase of 1·9 per cent. only, while simultaneously the imports of pig iron into Germany during these periods have risen from 383,223 tons in the first eight months of 1899 to 485,195 tons in 1900, and the exports have fallen from 125,461 tons to 82,549 tons. If the imports of pig iron should continue at the same rate, it would

* *Stahl und Eisen*, vol. xx. p. 283.

† *Ibid.*, pp. 1029–1033.

which show how great has been the increase in the general iron trade exports of the United States during the first seven months of 1900 as compared with the similar period of 1899. Fourteen different kinds of iron and steel ingots, slabs, and manufactures are quoted. The total quantity of these which was exported from the United States in the first seven months of 1899 was 365,704 tons, and in the same period of 1900, 421,020 tons; the exports of steel rails included in these totals having been respectively 129,501 tons and 222,308 tons. The ocean freight charges from the United States to Germany are now about £1 per ton.

The production of basic ingot metal in Germany has been as follows :—

| Year. | Converter. | Open-Hearth. | Totals. |
|----------------|--------------|--------------|--------------|
| | Metric Tons. | Metric Tons. | Metric Tons. |
| 1894 | 2,342,161 | 899,111 | 3,241,272 |
| 1895 | 2,520,396 | 1,018,807 | 3,539,203 |
| 1897 | 3,234,214 | 1,304,423 | 4,538,637 |
| 1899 | 3,973,225 | 1,693,825 | 5,667,050 |

It will be seen that the percentage increase in out-turn has been very great, especially in the case of the open-hearth metal. In another table is shown the production of castings. In 1891 the castings made amounted to 1,050,217 tons, and in 1899 to 1,769,101 tons. The finished manufactures of weld iron and of ingot iron were respectively 1,411,653 tons and 1,841,063 tons in 1891, and 1,103,740 tons and 4,791,022 tons in 1899. The latter has therefore shown an enormous increase during this period, while the weld iron shows a considerable diminution.

The last table given relates to the German imports and exports of iron and iron wares, not including pig iron, scrap, or machines, the figures for each of the years 1891–1899 being given, and also a comparative statement for the first eight months of 1899 and 1900. These figures were as follows :—

| Year. | Imports. | Exports. |
|----------------|--------------|--------------|
| | Metric Tons. | Metric Tons. |
| 1891 | 76,485 | 1,034,808 |
| 1895 | 68,673 | 1,307,752 |
| 1897 | 103,658 | 1,263,963 |
| 1898 | 164,046 | 1,274,693 |

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The production of coal in Prussia has increased from 64,373,816 tons in 1890 to 94,778,252 tons in 1899, while the output of the Ruhr basin has increased from 35,517,083 tons to 54,494,000 tons during the same period, and that of the collieries belonging to the Rhenish-Westphalian syndicate from 33,539,230 tons in 1893 to 48,024,014 tons in 1899. The production of the Saar collieries was 6,212,540 tons in 1890, and that of the collieries of Upper Silesia in the same year 16,870,886 tons, the figures for 1899 being respectively 9,025,071 tons and 23,527,317 tons. Since 1892 the output of coal in each district has shown a steady increase year by year. A number of other details are also given.

As an introduction to the German mining exhibits at Paris, an excellent essay on the mining industry of Germany has been prepared by C. Engel.* A good idea of the importance of the industry is afforded by the sum paid as wages. In 1897, the last year for which exact and complete statistics are available, the insurance against accidents in mines and works included 455,417 undertakings and a total of 6,043,000 workmen, the wages being £212,681,030. The Miners' Association alone comprised 1838 mines and 459,000 workmen (7·7 per cent. of the total), whilst the wages represented 10·8 per cent. of the total. The seven Metallurgical Associations comprised 21,681 works and 675,000 workmen (11·2 per cent. of the total), whilst the wages represented 14·2 per cent. of the total. The growth of the mining industry is well shown by the following figures dealing with the Dortmund district:—

| Year. | Number of Collieries. | Production. Thousands of Tons. | Number of Miners. |
|----------------|-----------------------|--------------------------------|-------------------|
| 1792 | 154 | 177 | 1,357 |
| 1800 | 158 | 231 | 1,546 |
| 1830 | 172 | 571 | 4,457 |
| 1850 | 198 | 1,606 | 12,741 |
| 1870 | 220 | 11,813 | 51,891 |
| 1890 | 177 | 35,469 | 127,794 |
| 1898 | 168 | 51,002 | 191,846 |

Imports and Exports.—The imports and exports of the German Customs Union included the following in the year 1899 : †—

* German Official Catalogue.

† *Oesterreichische Zeitschrift für Berg- und Hüttenwesen*, vol. xlviii. p. 199.



The total value of these iron and steel imports, excluding iron ore, was £4,350,300 in the first half of 1899, and £5,768,000 in the first half of 1900, while the values of the similar exports were for these periods respectively £16,481,950 and £18,022,100.

Iron Trade Statistics of Upper Silesia.—In the year 1899,* there were in Upper Silesia 59 collieries provided with 1086 steam-engines of 102,122 horse-power, the similar figures for 1898 having been respectively 55, 1035, and 91,807. The workpeople employed numbered 63,115, or 6·2 per cent. more than in the previous year. Of this number 3783 were females. The average wages earned during 1899 per workman over sixteen was £45, 16s., and under sixteen, £13, 17s. A woman earned on the average £14, 10s. The production of coal was 23,527,317 metric tons, an increase of 1,025,118 tons, or 4·6 per cent. as compared with the production in the previous year. The iron ore mines numbered 43, an increase of one on the year. The workpeople employed numbered 2982, an increase of 96, and the production amounted to 435,110 tons, this representing an increase on the year of 4·0 per cent. The average quantity of coal wound per workman was 372·8 tons, and of iron ore 140·57 tons. The production of coal was as follows in those parts of the Silesian coal basin which are not parts of the German Empire :—

| District. | Production. | Increase. |
|---------------------------------|--------------|--------------|
| | Metric Tons. | Metric Tons. |
| Moravian Ostrau | 6,252,163 | 295,305 |
| Jaworzno | 869,320 | 97,095 |
| Russian Poland | 3,904,996 | 17,709 |
| Add for Upper Silesia proper . | 23,527,317 | 1,025,118 |
| Total for the whole basin . . . | 34,553,796 | 1,435,227 |

The coke blast-furnaces in Upper Silesia proper numbered 40, an increase of three. Of these, 34 were in blast, this being an increase of two. The workpeople employed numbered 4588, an increase of 570, and 744,466 tons of pig iron were produced, an increase of 9·7 per cent. on the year. While the production of forge pig iron diminished by 3 per cent. of the total production, that of basic pig iron has risen 16·7 per cent. The exports of pig iron to Austria-Hungary amounted to only 700 tons, or 520 tons less than in the preceding year. A workman over sixteen averaged a wage for 1899 amounting to about £46, 10s.

* *Oesterreichische Zeitschrift für Berg- und Hüttenwesen*, vol. xlviii. pp. 326-329.

| Number of children | Number of adults |
|--------------------|------------------|
| 0 | 0 |
| 1 | 1 |
| 2 | 2 |
| 3 | 3 |
| 4 | 4 |
| 5 | 5 |
| 6 | 6 |
| 7 | 7 |
| 8 | 8 |
| 9 | 9 |
| 10 | 10 |

The output of the blast-furnaces shows an increase of 16 per cent. on the year. Eighteen per cent. of this total output was subject to further treatment within the district, while 65 per cent. went to other parts of Germany, and 17 per cent. to foreign countries.

The Iron Industry of Lorraine.—It is proposed to canalise the river Moselle from Metz to Coblenz, and Heidegger,* in describing the proposal, shows how it would advantage the iron industry of Lorraine. In 1885 there were in Lorraine some 18 blast-furnaces, using about 500,000 tons of coke a year. Now there are about 45 furnaces, and the annual consumption of coke is far more than three times as much as it then was. The production of iron ore in Lorraine was as follows in 1899 :—

| | Metric Tons. |
|---|------------------|
| Smelted in Lorraine | 3,739,536 |
| Sent by railway to the Saar | 1,348,804 |
| Sent to Westphalia and the Rhine district | 701,665 |
| Sent to Luxembourg | 550,306 |
| Sent to France | 477,696 |
| Sent to Belgium | 154,683 |
| Total | 6,972,690 |

The production of iron at the Lorraine blast-furnaces amounted to :—

| | |
|----------------------------|-----------|
| Pig iron | 1,290,164 |
| Weld iron | 70,324 |
| Ingot iron | 234,938 |
| Foundry products | 17,946 |

In addition there were also exported from Lorraine 72,330 tons of semi-manufactures, steel billets, &c. The workpeople employed in the mines and smelting works of Lorraine in 1899 numbered over 22,500, these being distributed as follows :—

| | Number. |
|------------------------------------|---------------|
| Mines | 8,638 |
| Blast-furnace plants | 7,568 |
| Weld and ingot ironworks | 5,929 |
| Foundries | 400 |
| Total | 22,535 |

There were also employed at various other works in Lorraine 4248 workpeople. These works included those making ground basic slag and slag bricks, of which considerable quantities are now being made.

The author deals at much length with the question of the commercial advantages which would be derived from this canalisation of the Moselle, and with the cost and other details of the scheme.

* *Stahl und Eisen*, vol. xx. pp. 805-814.

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— *Journal of the American Medical Association*, 1967, 201:1033-1034

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There was also produced :—

| | Tons. |
|---------------------|---------|
| Graphite | 5,196 |
| Petroleum | 68 |
| Ochre | 9,287 |
| Fireclay | 271,792 |

The Bavarian metallurgical production in 1899 comprised :—

| | Tons. |
|---------------------|---------|
| Pig iron | 83,821 |
| Cast iron | 92,458 |
| Bar iron | 61,414 |
| Iron wire | 111 |
| Steel | 134,007 |

The Krupp Steelworks.—An account is published * of the Krupp Steelworks at Essen. The Krupp Company owns steelworks at Essen, at Annen on the Weser, at Buckau near Magdeburg; four blast-furnace plants at Duisburg, Neuwied, Engers, and Rheinhausen; a smelting works and machine shops near Sayn; four collieries; over 500 iron ore mines in Germany, of which 11 are deep mines with complete winding and general plants; various iron ore mines near Bilbao; a gun-proving ground some 10 miles in length near Meppen, and with the possibility of increasing the range to about 15 miles; three ocean-going steamships, quarries, claypits, sandpits, &c. It also works the shipbuilding and machine construction works of the Germania Company at Berlin and Kiel. The cast-steel works at Essen are chiefly employed in gun construction. Down to the end of 1899, 38,478 guns had been constructed at this works, which has in operation two Bessemer plants provided with 15 converters, four open-hearth plants, and numerous other furnaces and shops. Altogether some 1700 different furnaces, smith's fires, &c., were in operation at this works in 1899, together with 4000 different machines and 132 steam-hammers, varying from 0·1 ton to 50 tons falling weight, their total falling weight being 269 tons. There were also in use over 30 hydraulic presses, two of which were each of 5000 tons power, one of 2000, and one of 1200 power. The total horse-power of the various steam-engines used was 41,213, and there were in use 558 cranes with a total carrying power of 5963 tons. The total quantity of coal and coke consumed by the Krupp Company during the year by all its works, steamers, &c., was 1,570,483 tons. The Rheinhausen blast-furnace plant possesses three blast-furnaces, each of which produces on the average 230 tons of pig iron in twenty-four

* Annual Report of the Essen Chamber of Commerce; *Stahl und Eisen*, vol. xx. p. 926.

[illegible]

1. The first step in the process is to identify the problem or issue that needs to be addressed. This involves gathering information and understanding the context of the problem.

2. Once the problem is identified, the next step is to define the objectives and goals of the project. This helps to clarify what needs to be achieved and provides a clear direction for the team.

3. The third step is to develop a plan or strategy to address the problem. This involves breaking down the problem into smaller, manageable tasks and determining the resources needed to complete each task.

4. The fourth step is to implement the plan. This involves putting the strategy into action and monitoring progress to ensure that the project is on track.

5. The final step is to evaluate the results of the project. This involves assessing the outcomes against the objectives and goals and identifying any areas for improvement.

1. The first part of the document is a header section containing the title "THE EFFECTS OF THE 1990S REFORMS ON THE ECONOMIC GROWTH OF CHINA" and the author's name "JIANHONG ZHANG".

2. The second part is the abstract, which states: "This paper examines the effects of the 1990s reforms on the economic growth of China. The results show that the reforms have had a significant positive impact on economic growth, particularly in the private sector."

3. The third part is the introduction, which discusses the background of the reforms and the objectives of the study.

4. The fourth part is the methodology, which describes the data sources and the econometric models used in the analysis.

5. The fifth part is the results, which presents the findings of the study, including the estimated coefficients and the statistical tests.

6. The sixth part is the conclusion, which summarizes the main findings and provides some policy implications.

7. The seventh part is the references, which lists the sources used in the paper.

8. The eighth part is the appendix, which contains additional data and results.

9. The ninth part is the endnotes, which provide further details on the methodology and results.

10. The tenth part is the index, which lists the topics covered in the paper.

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material used is shown by aid of a number of illustrations showing the result of various collisions, &c. The larger steamship companies are also briefly mentioned. It is incidentally pointed out that the *Kaiser Wilhelm der Grosse* consumes 3000 tons of coal in a single passage between Europe and America.

Iron Ore in Luxemburg.—Although the Grand Duchy of Luxemburg is small, it possesses great riches in iron ores of excellent quality. The growth of the mining industry is well shown by figures given by T. Kellen.* In 1870 the output of iron ore was 911,700 tons, whilst last year it was 6,014,400 tons, valued at £649,500. The oolitic iron ore, known as minette, extends over a zone 10 to 15 miles in width and 60 miles in length from Luxemburg over German Lorraine into French Lorraine. The percentage of iron varies from 30 to 40.

IX.—INDIA.

Mineral Statistics.—The statistics of the mineral production of India have been issued. The coal industry has expanded without a break from 2,168,500 tons in 1890 to 4,937,000 tons in 1899, a growth of 128 per cent. Coal of varying quality is found over a very extensive area in India. Of the yield last year about 79 per cent. came from Bengal, which contains important mines in the Raniganj district. The Nizam's territory, Assam, Central India, and the Central Provinces are at present the only other coal centres of note. For railways, steamers, mills, and factories Indian coal is extensively and increasingly used, and would be used still more widely but for the difficulties and expense of inland transport. Bombay, which requires large quantities of coal for its mills, is too remote from the chief mines to obtain the fuel economically, especially as British steamers carry coal thither under easy conditions as to freights. Hence the recent rise in coal imports into India in spite of increased production. In 1899–1900 422,000 tons were imported, of which Bombay Presidency (including Sind) took 369,000 tons; on the other hand, India exported 304,500 tons of her own coal from Bengal, Ceylon with 181,500 tons and the Straits Settlements with 87,000 tons being the chief purchasers.

Out of a total Indian production of 33,000,000 gallons of petroleum

* *Der Gnom*, September 8, 1900.

The image is a high-contrast, black and white scan of a document page. It appears to be a ledger or a form with a grid-like structure, but the details are obscured by numerous small, dark, irregular marks and artifacts. These marks are scattered across the entire page, with some appearing as small clusters and others as single dots. The overall texture is grainy and noisy, typical of a poor-quality scan of a physical document. There are no legible text or figures visible.

1. *Chlorophyll a* and *Chlorophyll b* were determined by the method of Lichtenthaler and Whistler (1973).

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At the Paris Exhibition the Italian Department of Mines showed a well-arranged and carefully selected typical collection of Italian minerals, geological maps and mine plans. The educational value of this collection was greatly enhanced by the catalogue,* covering 261 closely printed pages. It contains details of the Italian mining and metallurgical industries which render it a treatise of permanent value. The collection is the most complete representation of the mineral resources of Italy ever got together, the number of specimens amounting to 1053. The catalogue of these covers nearly fifty pages. The following 110 pages are devoted to descriptions of the principal Italian deposits of economic importance. The third section, twenty-six pages, is devoted to descriptions of the metallurgical and chemical industries. The fourth section contains the Italian mineral statistics for the years 1860 to 1899, whilst the last section gives details of the constitution of the Department of Mines.

Tonietti † has prepared a report on the iron ore mines of Elba.

XI.—JAPAN.

Industrial Development.—B. H. Thwaite ‡ gives a detailed description of the new Japanese Government iron and steel works.

The length of the railways in Japan was only 18 miles in the year 1872–73. In the years 1898–1899 the length was as much as 3430 miles.§

XII.—RUSSIA.

Iron Trade Statistics.—The Russian Bureau of Statistics has published the iron trade returns for 1899. The production of pig iron amounted to 163,115,811 poods, or 21·6 per cent. more than in 1898. The production of wrought iron was 34,553,916 poods, and that of steel 80,667,140 poods. The production of petroleum increased from 69,918,325 poods in 1898 to 80,667,140 poods in 1899.

* "Catalogo della mostra fatta dal Corpo Reale delle Miniere all' Esposizione universale del 1900 a Parigi," 1900 (Rome: Ministero di Agricoltura).

† *Iron and Steel Trades Journal*, vol. lxvi. p. 588; *Iron and Coal Trades Review*, vol. lxi. p. 14.

‡ *Indian and Eastern Engineer*, March 1900.

§ *Japan Weekly Mail*; *Stahl und Eisen*, vol. xx. p. 614.

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from spouting wells in the first half of 1899. The total number of producers engaged in the oil industry is now 135, as compared with 114 in the same period of 1899, whilst the bore-holes numbered 1497 in 1900 as compared with 1197 in the previous year. The average yield per bore-hole was 185,000 poods in the first half of 1900, as compared with 220,000 poods in 1899. The exports of oil in the first half of 1900 amounted to 209,000,000 poods, as compared with 200,000,000 poods in the similar period of the previous year.

Attention is directed * to the increase in the consumption of petroleum on the Russian railways. In 1885 they consumed 5,788,000 poods of petroleum residues; in 1890 the consumption amounted to 17,654,000 poods, and in 1896 it had reached 62,569,000 poods.

Manganese Ore.—The exports of manganese ore from Poti in 1899 amounted to 411,197 metric tons. Of this quantity 118,049 tons were sent to the United Kingdom.†

Mineral Industry of Siberia.—An exhaustive report on the mineral resources of Siberia has been published by E. Glasser,‡ a French mining engineer. Siberia possesses, he shows, important mineral deposits. There are, too, some fine deposits of iron ore and coal. Half the vast area of Siberia has not yet been explored.

The Siberian railway is tending to open up the country considerably, and various machine-shops and foundries have recently been started there.§

XIII.—SPAIN.

The Iron Industry.—A recent Foreign Office report gives much statistical information as to the production of ore in Spain. The iron ore mined in 1899 amounted to 9,344,320 tons, as compared with 7,197,045 tons in 1898. The share of the Bilbao district for these two years was 7,568,085 and 5,850,085 tons respectively. The number of kilns in that district was 33, employed in producing 613,575 tons of roasted spathic ore. Full details are given.

A report of the general meeting of the Viscaya Company of Bilbao || has been published. The year 1899 was one of marked prosperity,

* *Revue Scientifique*, July 21, 1900.

† *Stahl und Eisen*, vol. xx. p. 614.

‡ *Annales des Mines*, vol. xviii. pp. 5-78.

§ *Stahl und Eisen*, vol. xx. pp. 714-715.

|| *Revista Minera*, vol. li. pp. 232-233.

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Signature and Report

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| | Metric Tons. |
|---|--------------|
| Crucible ingots and castings | 1,225 |
| Blister steel | 974 |
| Bar iron and steel | 116,506 |
| Nail and wire rod, hoop iron and steel | 103,604 |
| Otherwise shaped iron and steel in bars | 10,051 |
| Plates (not including sheets) | 19,688 |
| Tube blocks, hollow blooms, and billets | 19,901 |
| Coal | 239,344 |
| Number of blast-furnaces in blast | 141 |
| Average daily product per furnace | 13·43 |
| Average time per furnace in blast | 263 days |

The total number of active iron ore mines in Sweden in 1899 was 321, as compared with 329 in 1898. The production of iron ore, on the other hand, rose from 2,302,516 tons in 1898 to 2,434,606 tons in 1899. The workpeople employed numbered 3946 below ground, and 4791 at grass. The chief ore-producing districts were:—

| | Production. | |
|-----------------------|--------------|--------------|
| | 1899. | 1898. |
| | Metric Tons. | Metric Tons. |
| Norrbotten | 957,300 | 867,649 |
| Kopparberg | 771,140 | 751,038 |
| Orebro | 299,566 | 299,934 |
| Westmanland | 218,589 | 185,155 |

The total weight broken in 1899 was 3,991,638 tons, from which 2,420,160 tons of ore was obtained by separation. Of the ore obtained by deep mining, 2,165,156 tons, or 88·9 per cent., was magnetite, and 269,450 tons hæmatite.

The total number of blast-furnaces in operation in 1899 numbered 167 at 118 works, as compared with 171 at 120 works in 1898. Of these 141 were in blast for 37,031 days in 1899, and 143 for 39,847 days in 1898. The production was as follows:—

| | 1899. | 1898. |
|---|--------------|--------------|
| | Metric Tons. | Metric Tons. |
| Direct castings | 8,496 | 7,806 |
| Forge pig iron | 248,817 | 259,971 |
| Bessemer and open-hearth pig iron | 218,797 | 240,781 |
| Total pig iron, including above | 497,727 | 531,766 |

The production shows a diminution of 6·1 per cent. on the year as regards quantity, but its average value increased.

1. The first part of the report is a general introduction to the subject of the study. It discusses the importance of the study and the objectives of the research.

2. The second part of the report is a detailed description of the methodology used in the study.

3. The third part of the report is a discussion of the results of the study.

4. The fourth part of the report is a conclusion and a summary of the findings of the study.

5. The fifth part of the report is a list of references and a bibliography of the sources used in the study.

6. The sixth part of the report is a list of appendices and a bibliography of the sources used in the study.

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10. The tenth part of the report is a list of appendices and a bibliography of the sources used in the study.

The following is a list of the sources used in the study:

1. The first source is a book by [Author] published in [Year].

The paper is illustrated by portraits of Baron Tamm, R. Åkerman, and J. C. Kjellberg. There are also photographic views of the exterior, of the reception-room, and of the meeting-room of the Jernkontor on the occasion of the visit of the Iron and Steel Institute, with drawings of the official uniform of Swedish ironmasters, of the medal awarded to Pehr Lagerhjelm in 1856, of that struck in honour of Gustaf Ekman in 1877, and of the frieze of the Jernkontor building.

The Iron Industry of Norway.—The exports of iron ore from Norway have been as follows :—

| Year. | Metric Tons. |
|----------------|--------------|
| 1897 | 4242 |
| 1898 | 4601 |
| 1899 | over 12,000 |

Of the exports in 1899, which amounted to rather more than 12,000 tons, 9600 tons were from the Fens mines near Ulefos. These mines are now being put into operation again after having been shut down for a lengthened period. From Soggendal iron ores are exported that contain 40 per cent. of titanitic acid. The Näs crucible steelworks gave employment during 1899 to a hundred workpeople, and was in full operation during the year. No nickel works were at work during 1899, but an important discovery of nickel ore was made near Fåo on the west coast. The ore is a magnetic pyrites containing some 2 per cent. of nickel and 2·5 of copper in its assorted condition. The lode is 5 or 6 yards wide. The total number of workpeople employed at all the mines and metallurgical works in Norway in 1899 was about 2650, of which 2250 were at copper-mines or copperworks, the value of the products being 4,900,000 crowns.*

J. H. L. Vogt † of Christiania urges the possibility of creating an iron industry in Norway.

According to the Norwegian *Veritas*, there were forty-seven ships under construction in Norway on July 1, 1900. Of these forty-four were steamers of 37,920 tonnage, thirty-seven of these being of steel, their tonnage being 33,700. Only three small sailing ships were being built, their total net tonnage being only 510.‡

* *Oesterreichische Zeitschrift für Berg- und Hüttenwesen*, vol. xlviii. p. 200.

† *Centralblatt der Walzwerke*, July 28, 1900.

‡ *Stahl und Eisen*, vol. xx. p. 1067.

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Coal.—D. Bellet * has published an important article on the part of the United States in the world's coal production.

Tables of production † show that in 1899 the United States surpassed Great Britain for the first time in the production of coal.

Cost of Production.—F. Lürmann, jun., ‡ gives a number of details as to the cost of production of basic pig iron and basic steel in the United States. The first relates to a monthly out-turn of 10,282 tons, and the latter to a monthly production of 9668 tons. This latter is stated to be the actual cost for the year 1897. The total cost of the metric ton of pig iron is placed at about £2, 5s., and of the ton of basic ingots about £3, 12s. In the latter case, however, allowance has to be made for the basic slag and scrap. This reduces the actual cost to rather over £3, 7s. per ton.

James A. Green § discusses the past and future of pig iron. After pointing out that the United States produce the greatest amount of pig iron in the world, he declares that, in order to profit by this great advantage, Americans should turn out the most perfect manufactures of pig iron.

George H. Hull || discusses industrial depressions and the pig iron reserve. He points out the difference between a panic caused by low prices and a depression caused by high prices, and presents statistics showing a close connection between abnormal prices for iron as well as reasons for great depression. He proposes a reduction of iron prices and the creation of a reserve supply as efficient means for recovering stability.

Shipbuilding.—At January 1, 1900, there were 109 steel steamers under construction or arranged for at the wharves on the Atlantic and Pacific coasts. These will have a total of 322,413 tons displacement, and consist of 59 trading steamers of 182,100 tons and 50 war vessels of 140,313 tons. In addition, Congress has arranged for six other war vessels of 76,500 tons displacement. Ten only of the new trading steamers are intended for foreign trade. ¶

Some interesting statistics regarding the traffic on the American great lakes are given. ** The Sault-Sainte-Marie, joining Lake Superior to Lake Huron, is the busiest canal in the world. In 1869 the number of

* *Moniteur des Intérêts Matériels*, vol. l. p. 3137.

† *Engineering and Mining Journal*, vol. lxi. pp. 644-645.

‡ *Stahl und Eisen*, vol. xx. p. 738.

§ *Iron and Steel Trades Journal*, vol. lxi. pp. 519-520.

|| *The Engineering Magazine*, vol. xix. pp. 641-654.

¶ *Stahl und Eisen*, vol. xx. pp. 715-716.

** *Revue Scientifique*, July 14, 1900.

1. The first part of the document is a list of the names of the persons who have been appointed to the various offices of the city of New York.

2. The second part of the document is a list of the names of the persons who have been appointed to the various offices of the city of New York.

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4. The fourth part of the document is a list of the names of the persons who have been appointed to the various offices of the city of New York.

A similar summary showing the production of pig iron is as follows:—

| Country. | Year. | Production in Tons. |
|---------------------------------|-------|---------------------|
| United Kingdom | 1899 | 9,421,435 |
| Austria | 1898 | 957,836 |
| Hungary | 1898 | 469,404 |
| Boemia | 1898 | 15,366 |
| Belgium | 1899 | 1,024,756 |
| Canada | 1899 | 94,077 |
| France | 1899 | 2,567,388 |
| Germany and Luxemburg | 1899 | 8,143,132 |
| Italy | 1898 | 12,387 |
| Japan | 1897 | 57,678 |
| Russia | 1898 | 2,193,750 |
| Spain | 1899 | 295,840 |
| Sweden | 1899 | 497,727 |
| United States | 1899 | 13,620,703 |

Iron Consumption.—According to the calculations of the Society of German ironmasters,* the production of pig iron per head of population in 1899 was as follows:—

| | Lbs. |
|---------------------------|------|
| Germany | 330 |
| Great Britain | 505 |
| France | 145 |
| Austria-Hungary | 67 |
| Belgium | 322 |
| Sweden | 244 |
| Italy | 1 |
| Russia | 46 |
| United States | 405 |

Imports and Exports.—Official statistics † show that the imports (in tons) of the leading European iron-producing countries in 1899 were:—

| Country. | Iron Ore. | Pig Iron. | Iron and Steel. |
|---------------------------|-----------|-----------|-----------------|
| Great Britain | 7,055,178 | 248,706 | 396,324 |
| Germany | 4,165,372 | 677,134 | 160,643 |
| Austria-Hungary | 212,412 | 126,370 | 35,559 |
| France | 1,950,665 | 181,476 | 60,628 |
| Belgium | 2,620,750 | 432,920 | 76,986 |

* *Verein Deutscher Eisen und Stahl Industrieller*, 1900, No. 18.

† *Ibid.*, 1900, No. 18, p. 88.

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World's Production of Petroleum.—In a paper by Oebbeke,* the world's production of petroleum last year is stated to have been as follows :—

| | Tons. |
|-------------------------|-----------|
| Russia | 8,960,000 |
| United States | 8,745,000 |
| Galicia | 350,000 |
| Sumatra | 327,000 |
| Roumania | 300,000 |
| Canada | 110,000 |
| Java | 101,000 |
| India | 57,000 |
| Japan | 30,000 |
| Germany | 26,500 |
| Peru | 11,360 |
| Italy | 3,790 |

The consumption is estimated at :—

| | Tons. |
|---------------------|---------|
| England | 803,425 |
| Germany | 587,444 |
| Japan | 202,112 |
| China | 168,522 |
| Brazil | 77,824 |
| Australia | 77,575 |
| France | 48,583 |

World's Production of Nickel and Aluminium.—The world's production of nickel and aluminium has been as follows in the years mentioned :—

| | Production. | | | |
|---------------------|--------------|--------------|--------------|--------------|
| | 1896. | 1897. | 1898. | 1899. |
| | Metric Tons. | Metric Tons. | Metric Tons. | Metric Tons. |
| Nickel | 4427 | 4758 | 6398 | 7360 |
| Aluminium | 1660 | 3394 | 4034 | 5748 |

The value of the nickel made in 1899 was about £920,000, and of the aluminium £630,000.†

The World's Miners.—The number of persons at the present time occupied in mining throughout the world is estimated † at 4,355,204. Great Britain heads the list with 875,603. Then follows Germany with 498,569, the United States with 444,578, India with 310,888, Ceylon with 310,210, France with 292,227, Belgium with 160,150, and Japan with 118,517. Before the war the Transvaal had 100,000 miners.‡

* *Glückauf*, vol. xxxvi. pp. 636-639.

† *Stahl und Eisen*, vol. xx. pp. 1122-1123.

‡ *Der Gnom*, August 4, 1900.

The average cost of the kilometre of line in Europe is placed at £14,502, while the total cost of all the lines of railway in the world is estimated at as much as £7,439,599,356. Detailed statements as to all the different countries are shown in tabular form.

The World's Iron Trade.—H. J. Skelton * discusses the competitive outlook in the world's iron and steel trades, particularly for the British iron trade, and gives the statistical position of the principal iron-producing countries of the world as follows :—

| | 1895.
1=1000
Tons. | 1899.
1=1000
Tons. | Increase per
Cent. |
|---|--------------------------|--------------------------|-----------------------|
| United Kingdom— | | | |
| Output of coal | 189,661 | 220,085 | 16·6 |
| Make of pig iron | 7,703 | 9,305 | 20·7 |
| Make of steel | 3,289 | 4,865 | 47·6 |
| Export of iron and steel | 2,835 | 3,717 | 30·7 |
| Consumption of iron ore | 17,500 | 20,482 | 17·04 |
| Value of iron and steel exports £ | 19,680 | 28,093 | 42·2 |
| Value of machinery exports £ | 17,300 | 19,650 | 13·5 |
| Ships launched | 951 | 1,713 | 25·02 |
| Germany— | | | |
| Output of bituminous coal | 79,169 | 101,621 | 28·3 |
| Make of pig iron | 5,464 | 8,117 | 48·5 |
| Make of steel | 3,961 | 6,290 | 58·8 |
| Exports of iron and steel | 1,528 | 1,244 | 12·0 |
| Output of iron ores | 12,349 | 17,989 | 45·6 |
| Value of iron and steel exports £ | ... | 18,174 | ... |
| Value of machinery exports £ | ... | 9,982 | ... |
| Tonnage of machinery exports | 158 | 226 | 43·0 |
| United States— | | | |
| Output of coal | 172,500 | 230,800 | 33·4 |
| Make of pig iron | 9,446 | 13,621 | 44·7 |
| Make of steel | 6,115 | 10,150 | 65·9 |
| Exports of iron and steel | ... | 779 | ... |
| Consumption of iron ores | 17,253 | 22,000 | 27·5 |
| Value of iron and steel exports } . . . \$ | 32,000 | 150,000 | 368·7 |
| Value of machinery exports } | | | |
| Belgium— | | | |
| Output of coal | 20,457 | 21,918 | 71·4 |
| Make of pig iron | 829 | 1,036 | 24·9 |
| Make of steel | 454 | 730 | 60·7 |
| Exports of iron and steel | 489 | 610 | 24·7 |
| Consumption of iron ores | 2,282 | 2,903 | 27·2 |
| Value of iron and steel exports £ | | | |

The main points in which Great Britain is behind her principal competitors are :—Scientific organisation, economy of transport, use of machinery, and training of workmen, and these are discussed in some detail. The necessity for standard sections is strongly insisted upon.

* Paper read before the British Iron Trade Association, through the *Iron and Coal Trades Review*, vol. ix. pp. 1125-1127.

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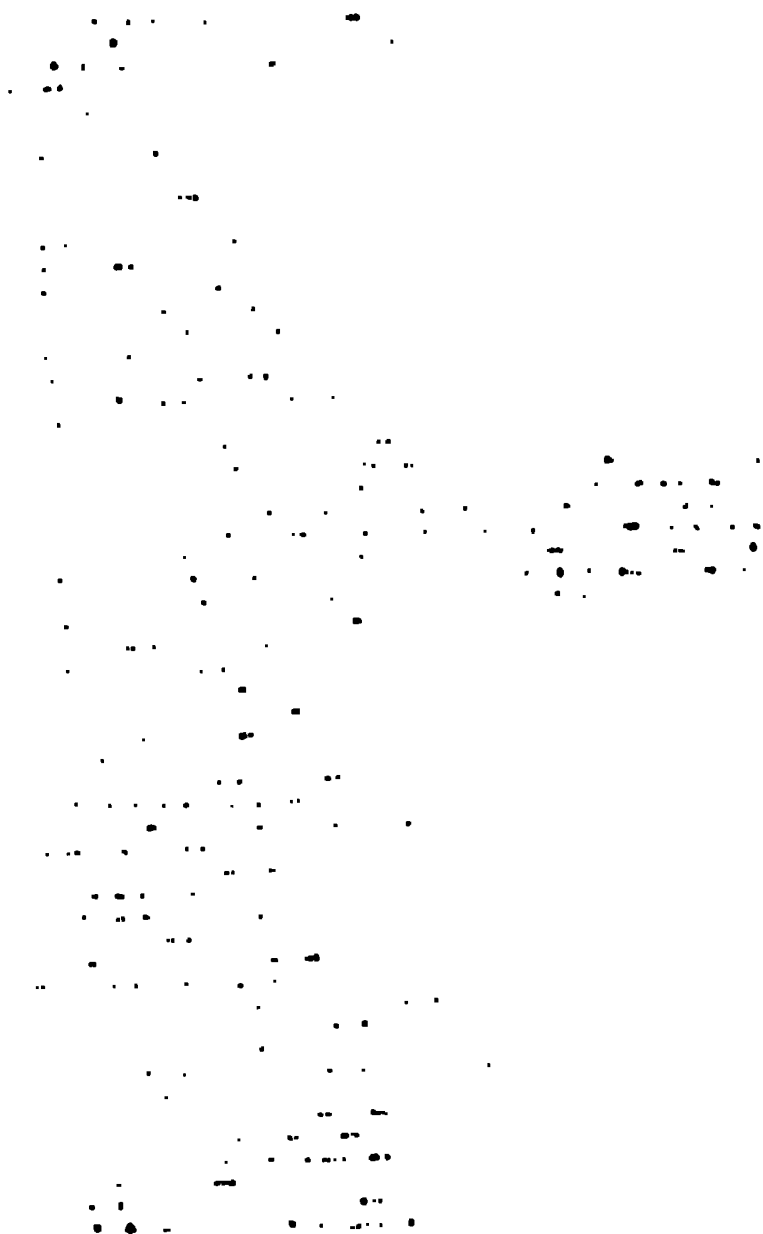
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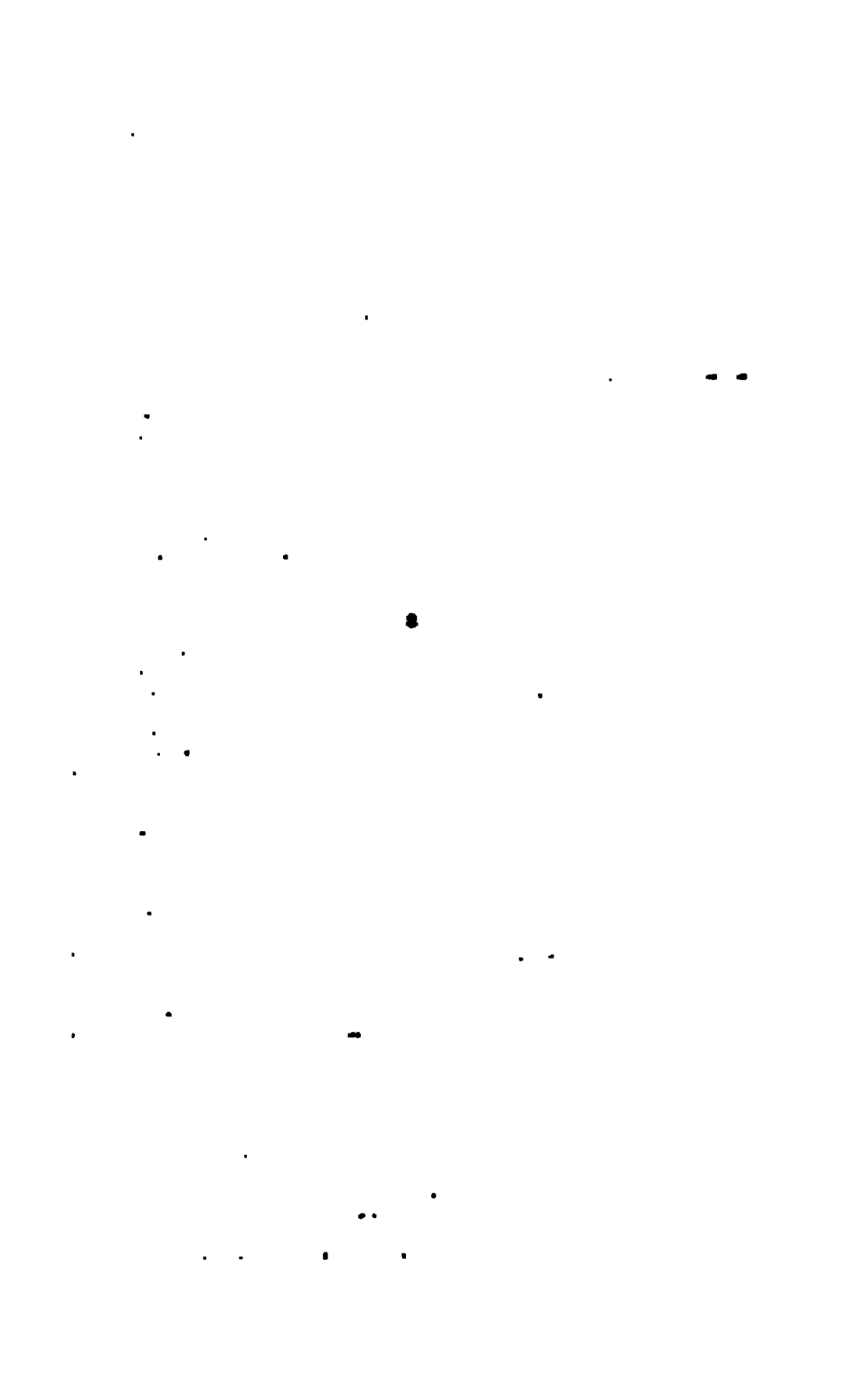
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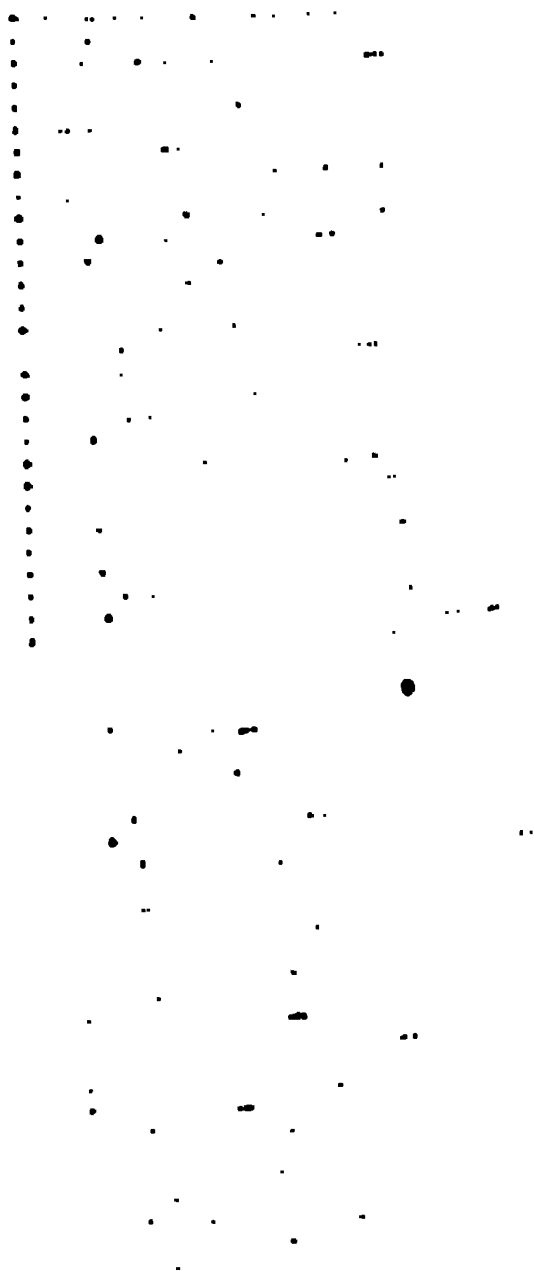
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